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Report on..... destructive distillation of peat. 1851

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REPORT

ON THE

NATURE AND PRODUCTS

OF THE PROCESS OF THE

DESTRUCTIVE DISTILLATION OF PEAT,

CONSIDERED SPECIALLY

WITH REFERENCE TO ITS EMPLOYMENT AS A BRANCH OF
MANUFACTURING INDUSTRY.

MADE TO

THE RIGHT HONOURABLE THE CHIEF COMMISSIONER OF WOODS,

BY

THE DIRECTOR OF THE MUSEUM OF IRISH INDUSTRY.

APRIL 8, 1851.

Presented to both Houses of Parliament by Command of Her Majesty.

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TO THE RIGHT HONOURABLE THE LORD SEYMOUR,
CHIEF COMMISSIONER OF WOODS.

My Lord,

I have the honour to submit to your Lordship the Report of the experiments on the process of distilling peat, with a view to ascertain the practical advantage of that process, which, in pursuance of your Lordship's instructions, have been conducted in the Museum of Irish Industry, in order to afford satisfactory information on the subject.

Trusting that the manner in which the investigation has been carried on, and the conclusions arrived at in the Report, may appear satisfactory to your Lordship,

I have the honour to be, my Lord,

Your obedient servant,

ROBERT KANE,

Director of the Museum of Irish Industry.

REPORT

ON

THE NATURE AND PRODUCTS OF THE PROCESS OF THE DESTRUCTIVE DISTILLATION OF PEAT.

Applications having been made by foreign authorities, and by individuals interested in industry in Ireland, for information regarding those processes for converting ordinary peat into valuable commercial products, to which public attention had been so strongly directed by the statements made in Parliament and elsewhere, the propriety of having such experiments instituted as should afford that information was brought under the notice of the Right Honourable the Chief Commissioner of Woods, on the suggestion of his Excellency the Earl of Clarendon; and his Lordship's sanction having been received to proceeding with the inquiry, the experimental examination of the conditions of that process, and of its products, was undertaken and completed by the chemical officers of the museum under my direction; and I have the honour now to report the results of that inquiry, as well as the consequences therefrom deducible.

The process in question, for distilling peat on such a scale as to form a department of manufacturing industry of national importance, has its origin in the special proposition patented by Mr. Rees Reece, to distil the material by the heat generated from its own combustion in high blast furnaces, nearly similar to those used in the iron-smelting districts. An investigation of the nature and circumstances of such a process should however include two essentially distinct features: the one the scientific examination of the results of the process of destructive distillation with the material, peat, which had not, under that point of view, hitherto obtained much notice; the other, the essentially practical consideration of the economy of that process conducted on a scale of manufacturing industry with a view to profit. Of these two subjects of inquiry, although the latter is that on which public attention may be most fixed, and for which information may be most generally sought, yet it is evident that trustworthy and sufficient data for its discussion can only be obtained by the actual circumstances and results of the process having been first determined by exact experimental research, and it was therefore necessary to commence the inquiry by the study of the phenomena of the destructive distillation of peat, and the analysis of its products without immediate reference to any special object of manufacturing speculation.

In this respect it may appear singular that the chemical history of a material of so much practical interest should have remained hitherto almost unnoticed, but the well understood nature of the peat, intermediate to wood and coal, explains the fact of the special history of its distillation having been neglected. The phenomena of the destructive distillation of wood, and the constitution of its products, had been accurately determined by the labours of many chemists, and that process conducted on the great scale had led to the creation of extensive manufacturing industries of acid (wood vinegar, pyroligneous acid), kreosote, wood spirit (naphtha), wood charcoal, &c. On the other hand, the destructive distillation of coal had been long conducted on the great scale for obtaining the gas for illumination, and various collateral occupations had been created by the preparation of the other products of that distillation for commercial uses, as sal-ammoniac and sulphate of ammonia works, naphthaline and gas naphtha, lamp-black, cements, &c. These results so fully indicated to chemists what should be the resulting products of distilling peat, that the actual experimenting on that material was neglected, except in a few instances, and indeed in a scientific point of view, not unjustly, as, during the special inquiries now concluded, but few results of any commercial value have been obtained that are not in accordance with and explainable by the fact of the peat occupying in uses and composition a place intermediate to wood and coal.

This consideration of the analogy of constitution of the different materials employed as fuels, and the consequent similarity of the products of their destructive distillation, is of importance as it indicates the differences in the results of distilling peat, or wood, or coal, to be not in the nature but in the relative proportions of the products. It is thus of importance to recollect in reference to subjects subsequently to be considered, that the essential and characteristic feature in the processes for distilling peat is not the obtaining of new products, but for obtaining the same bodies that had been hitherto obtained from coal or wood, by means of a cheaper and more abundant material, and at a price so much reduced as to bring them into the market under circumstances sufficiently favourable to create a new and lucrative industry.

Such being the general nature of the processes into which it was considered desirable to inquire, I shall proceed to notice the means taken to arrive at satisfactory conclusions. It was necessary to regard—

1. The selection of the material to be operated on, in order that the specimens obtained should fairly represent the peat from every important locality, and of every characteristic variety.

2. The determination of the phenomena and results of the distillation of the peat in closed retorts, so as to ascertain the nature and quantity of the coke (peat charcoal), as well as the other products.

3. The determination of the phenomena and results of the distillation of the turf with air-blast, so as to burn the coke and represent the conditions of the manufacturing process proposed.

4. The separation and special examination of the several products, supposed to possess commercial value.

5. The discussion of the economic conditions of those processes, as compared with the processes by which similar products are obtained from other sources than peat.

For the objects of the present Report I have thought it most proper to place in an Appendix the detailed descriptions of the varieties of peat operated on, the tables of their constitution, the description in detail of the several series of experiments, and tables of the results, and the discussion of the analytical processes by which the various products were separated from one another and their quantities determined. Referring, therefore, for details, to the Special Report, drawn up with the assistance of Dr. William Sullivan and M. Alphonse Gages, the chemical officers of the museum, I shall in this Report limit myself to a more general notice of the course pursued, and of the conclusions to which the results obtained in the inquiry have been found to lead.

The inquiry being carried on in Dublin rendered the selection of characteristic varieties of peat peculiarly easy. The varieties of turf employed, in all twenty-seven kinds, were selected so as to represent as well diversities of constitution as differences of locality. In regard to constitution, three principal varieties were examined: the dense black or dark brown variety, which forms the lower strata of the deeper bogs, and which approximates closely to coal in composition; the upper or surface turf, which is almost pure moss and bog plants unaltered; and the intermediate moderately dense brown peat, in which the vegetable structure is quite evident, but the individual plants can no longer be separated. The peculiar differences in the results of the distillation of these several kinds of peat will be found fully illustrated in the special tables; but were found to be upon the whole confined within such narrow limits, as that for technical objects the produce of the distillation of the several varieties of peat may be considered to be almost the same.

The specimens operated on having been thus selected, so as to represent all important qualities of peat, and also all of the localities in which peat occurs under circumstances favourable to manufacturing industry, it may reasonably be expected that the results obtained may fairly be considered as applicable to any form or kind of the material that is likely to be employed for industrial objects in this country.

It being important that in an inquiry such as the present, the nature of the material operated on should be determined with full accuracy, there was instituted prior to the distilling processes, a complete analysis of each variety of peat to be employed. These analyses had mainly for object—1, To determine the amount and nature of the mineral ingredient of the peat; 2, to determine the amount and quality of coke to be expected from its perfect carbonization; and 3, to ascertain by its exact organic analysis, the proportions of its ultimate elements in order to check the quantity of ammoniacal products of its distillation against the proportion of elements of ammonia which the peat actually contained. This investigation of the chemical composition of peat, and of peat ashes from various districts, will be found in an agricultural point of view of considerable interest, as not merely the practical utility of the peat ashes themselves as manure, but the application of the peat charcoal, either by itself or as a recipient of animal manures, will be found very materially influenced by the nature and amount of those ashes, of which, however, we had obtained hitherto singularly little information of a trustworthy kind.

The sources, qualities, and chemical composition of the organic and the mineral portions of the peat having been thus determined, the next step in the inquiry was to ascertain the precise results of the destructive distillation carried on in close vessels, so as to collect all the products for examination, and observe all the phenomena of the process. To effect this a furnace was constructed nearly on the plan of the apparatus for preparing gas by distilling coal. An iron cylinder was laid horizontally, with the flame-bed and flues so disposed that the entire cylinder could be made red-hot. At the front of the cylinder the charge was introduced, and from the upper part in front a tube passed, carrying the products of the distillation to the condensing apparatus. As it was the object to obtain separately the products of different volatility and different natures, the condensation was effected by a series of large tinned-iron vessels, immersed in water, like a series of Wolf's bottles, and from the last vessel the tube passed to a worm contained in a barrel supplied with cold water. In no case was the water in this barrel sensibly warmed, the previous refrigeration having been complete, but the worm was found very useful in arresting small portions of the condensed liquids which were carried forwards mechanically by the current of gas, and were collected in a small vessel attached where the worm issued from the barrel, and provided with a stopcock for their removal; at the extremity of the tube the gases finally issued, and were generally set on fire as the most simple means of getting rid of them: proper observations as to their combustibility and constitution being of course made from time to time.

All the further details as to the construction of the apparatus, and the management of this process, will be found given in the appended special reports. I shall confine myself here to the general results. The object being to ascertain the necessary facts regarding the products of commercial value, the following was the course pursued:—

Specimens of turf representing the several ordinary varieties were separately experimented on, and the results examined.

The products of the distillation were collected as—

1. Charcoal.
2. Tar.
3. Watery liquids.
4. Gases.

The relative quantities produced by 100 parts of peat were found to be—

	Average.	Maximum.	Minimum.
Charcoal	29·222	39·132	18·973
Tarry products	2·787	4·417	1·462
Watery products	31·378	38·127	21·819
Gases	36·616	57·746	25·018

The peats yielding those proportions of products had been found to contain previous to distillation, as dried in the air, a quantity of hygrometric moisture, and to yield a proportion of ashes in 100 parts as follows:—

	Average.	Maximum.	Minimum.
Moisture	19·71	29·56	16·39
Ashes	3·43	7·90	1·99

The details of these examinations and the tabulated results will be found in the Appendix.

The several products of the distillation thus carried on were next specially examined for the several materials of which the quantities and commercial value had been the principal sources of the public interest of this inquiry. The description of the processes by which these bodies were separated from each other and their quantities ascertained, will be found in the special reports appended. The inquiry having reference, however, to the technical objects of the process, was carried on by examining the produce of

I. Tar, for —1. Volatile oils,
2. Fixed (less volatile) oils.
3. Solid fats, or paraffine.
4. Kreosote.

II. Watery liquids for—1. Acetic acid.
2. Ammonia.
3. Pyroxylic spirit.

III. Gases—For illuminating and heating power.

The following numbers will indicate the results obtained in average. All the details of the processes of separation, and the numbers of the individual experiments will be found in the special reports.

In seven-series of distillation in close vessels, there was obtained from 100 parts of peat—

	Average.	Minimum.	Maximum.
Ammonia	0·268	0·181	0·404
or as Sulphate of ammonia	1·037	0·702	1·567
Acetic acid	0·191	0·076	0·286
or as Acetate of Lime	0·280	0·111	0·419
Pyroxylic spirit	0·146	0·092	0·197
Volatile oils	0·790	0·571	1·262
Fixed oils	0·550	0·266	0·760
Paraffine	0·134	0·024	0·196

It is thus seen that the proportions of those products vary within wide limits, which are determined by differences of quality of the turf or temperature in the distillation. The precise degrees of influence exercised by each of these causes will be noticed specially hereafter.

Several trials were made to determine the amount of kreosote present in the tar, but although its presence could be recognized, its proportion was so minute as to render its quantitative estimation impossible. This circumstance constitutes an essential distinction of peat-tar from wood-tar, and indicates for the former an inferior commercial value, as the presence of kreosote, now so extensively employed, is an element in the estimate of the price of the tar obtained by distilling wood.

It will be understood that the materials indicated in the foregoing table by the names "fixed and volatile oils" are in reality mixtures of a variety of chemical substances of different volatilities and compositions—generally carbo-hydrogens—of which the further separation would be a labour of purely scientific curiosity, without having any bearing upon the objects of the present report. Although therefore, those liquids were carefully examined, and observations made regarding their chemical history, I shall not embarrass the present report by reference to them in any other point of view than as products of destructive distillation whose properties, analogous to the highly volatile and to the fixed oils, respectively, may give them a commercial value such as has been represented. I may remark also, that as a purely scientific question, the true nature of the solid fatty product is of much interest. The name paraffine has been given to this body, but in some of its characters it appears to deviate from those of the true paraffine, as described by Reichenbach to be obtained from wood-tar; those differences should, however, not contravene its commercial uses.

The inquiry so far carried on sufficiently established that the peat by destructive distillation in close vessels yielded the several products that had been described, and were identical, or closely analogous to those afforded in the distillation of wood or coal. The process in close retorts, however, being not at all that proposed or economically practicable for commercial purposes, it was necessary to proceed to determine whether the same varieties of peat, being distilled in a blast furnace, with a current of air, so that the heat necessary for the distillation was produced by the combustion of the peat itself, would furnish the same products, and whether in greater or in less quantities than in the process in close vessels.

For this purpose, the cylinder which in the former series of experiments had been set horizontally in the furnace, was placed surrounded by brickwork vertically, its mouth projecting a little at top, so that the tube for conveying away the products of the distillation passed horizontally from the top of the brickwork casing to the condensing apparatus. Near the bottom of the cylinder the brickwork left a space where the cylinder was perforated by an aperture 1½ inch diameter, to which the tube of a large forge bellows was adapted. The arrangement thus represented nearly the construction of an iron cupola. The cylinder being charged with peat, of which some fragments were first introduced lighted, and the blast being put on, the combustion spread, and the cover of the cylinder being screwed down, the distillation proceeded, the products passing with the current of air into the series of condensing vessels, and the gases and air finally being conducted by a waste pipe to the ashpit of a furnace where they were allowed to escape.

By this means there was obtained, on a moderate scale, a satisfactory representation of the condition of air-blast distillation of peat which has been proposed as the commercial process. In so carrying it on several interesting observations were made which will require to be noticed here in a general point of view, referring to the special report appended for details.

First, as to the nature and quantities of the products. The specimens of peat operated on were selected as similar to those employed in the former series of which the results have been quoted, and the products similarly treated were found to be, from 100 parts—

	Average.		Maximum.		Minimum.
Watery products	30·714	..	31·678	..	29·818
Tarry products	2·392	..	2·510	..	2·270
Gases	62·392	..	65·041	..	59·716
Ashes	4·197	..	7·226	..	2·493

These several products having been further examined, as in the former case, gave, from 100 parts of peat—

	Average.		Maximum.		Minimum.
Ammonia	0·287	..	0·344	..	0·194
or as					
Sulphate of ammonia	1·110	..	1·330	..	0·745
Acetic acid	0·207	..	0·268	..	0·174
or as					
Acetate of lime	0·305	..	0·393	..	0·256
Pyroxylic spirit	0·140	..	0·158	..	0·106
Volatile oils	1·059	..	1·220	..	0·946
Paraffine	0·125	..	0·169	..	0·086

It is now important to compare these average results with those of the former series obtained by distillation in close vessels; we obtain—

	Average produce from close distillation.		Average produce by air-blast distillation.
Ammonia	0·268	..	0·287
or as			
Sulphate of ammonia	1·037	..	1·110
Acetic acid	0·191	..	0·207
or as			
Acetate of lime	0·280	..	0·305
Pyroxylic spirit	0·146	..	0·140
Oils	1·340	..	1·059
Paraffine	0·134	..	0·125

More detailed comparative tables will be found appended; and it is thus seen that, notwithstanding the apparent differences in the nature of the process, and the construction of the apparatus, there is really no serious difference in the results; the products being the same, and not differing more in proportional quantity, whether obtained by close or by blast distillation, than different experiments made with the same apparatus differ amongst one another.

There is thus obtained the very important consequence that we may adopt as applicable to the blast distillation process all the investigations made regarding the products and circumstances of the process in close vessels, and it is easy to understand why it is so. The blast of air entering the bottom of the cylinder burns the portion of the peat with which it comes immediately into contact, and the heat so produced acts as the heat of an external fire should have acted to carbonize and distil the portion of peat lying immediately above; there is thus in the upper part of the furnace a simple distillation and cokeing of the peat; but in the lower part a combustion of the peat charcoal as it descends. This latter is, therefore, the fuel of the operation, and is used in the most direct and economical manner, as the coke is used in the cupolas or high furnaces of an iron-works.

It was found, however, that the volatile products of the distillation being in this case intermixed with so large a quantity of air and permanent gases, the condensation of the vapours became far more difficult than in the process with the closed retort; and in the first experiments it was found that very little tar was obtained, and the aqueous liquor was strongly acid, a re-action never observed with the process in close vessels: traces only of pyroxylic spirit was obtained, and altogether the volatile products appeared to have escaped condensation. It was, therefore, found to be necessary, in order to obtain trustworthy results, to provide additional means of condensation, not merely by cooling the products, but by washing the gases evolved, so as to separate the other products diffused through their volume. This was successfully accomplished by washing the gases evolved by contact with a considerable surface of cold water before escaping to the chimney.

There will be found in the special report some interesting details as to the presence of certain bodies, associated with the more important products, and which may be considered accidental, as having their origin either in unessential conditions of the process, or in the accidental presence of substances in the peat employed. Thus, in almost every case, the oily products were found to be contaminated by the presence of a quantity of sulphur, derived from gypsum or from iron pyrites in the peat. This sulphur gave to the oily products a disagreeable odour, especially if burned; and its removal required careful and peculiar chemical management. Similarly the quantity of ammonia obtained in the watery liquors was liable to variation, according as the proportion of azotized oily bodies changed with the circumstances of the distillation, as the peat, in its volatile tarry products, contained the same organic bases, rich in nitrogen, and capable of giving ammonia when decomposed, that are found in the coal gas tar.

Another peculiarity in the results of the air-blast distillation is one which may be found of importance in case the process becomes commercially employed. Among the products of the distillation is the butyric acid, an acid of animal origin (in butter), but also of occurrence as a product of peculiar fermentation. It is of very high interest to find this acid associated with the acetic acid, when produced by destructive distillation, but it is remarkable that it is produced in much larger quantities in the air-blast distillation, than when the process is carried on in close vessels. In the former case its proportion is such as to affect materially the characters of the acetic acid, from which its perfect separation is by no means easy. I am not aware what processes may have been devised for the purification of the rough acetic acid in the works projected by Mr. Reece; but it is certain that even more special attention will be necessary than in the case of the similar acid obtained by the distillation of wood.

It may thus finally be concluded that so far as the nature and quantities of the substances reported by Mr. Reece to be obtainable by the distillation of peat in air-blast furnaces, there appears no doubt of the feasibility of the results he proposes to obtain. It is, however, also found that there are associated with these products others which are impurities, whose separation may be difficult, and requiring special processes, which will deserve to be taken into account in considering the applicability of Mr. Reece's processes on the great scale.

Commercial Application of the Process.—In 1849 Mr. Reece, having brought his experiments on the destructive distillation of peat to a satisfactory issue, patented his invention of the process of distilling peat in an air-blast, and thereby obtaining certain products. His published specification will be found in the appendix, and it will be seen that he claims—first, causing peat to be burned in a blast, so as to obtain inflammable gases and other products; secondly, obtaining products of peat, which he terms paraffine and liquid paraffine, by operating on tar or pitchy matter, produced from peat as described. Mr. Reece's patent includes the description of the furnace and condensing apparatus he proposes to employ, but does not claim any particular construction.

In order to be able more satisfactorily to compare the results of Mr. Reece's operations with those of the experiments conducted under my own superintendence, I communicated to him the fact of my being engaged with the present inquiry, and invited him to afford information on some points which I suggested. I have to thank Mr. Reece for his immediate and satisfactory attention to my request; and I have placed in the appendix copies of my application and of his reply, to which I shall here only make general references.

The experiments which were carried on at Newtown Crommelin, in the north of Ireland, by Mr. Reece, for the purpose of determining the commercial utility of his process, as referred to in his replies, have apparently afforded all the practical evidence that had been obtained by him of the amount and nature of the products. In the prospectus of the company proposed by Mr. Reece these experiments were quoted, and reported to have been superintended by Dr. Hodges, Professor of Agriculture in the Queen's College, Belfast; and, being desirous to obtain the fullest information as to their nature, I addressed to Dr. Hodges some inquiries, to which he obligingly replied. His answers will be found appended, and I shall refer to them on occasion. We have thus in the practical results of the distillations at Newtown Crommelin the grounds of the calculations of quantities of produce, which Mr. Rees Reece has put forward, and they may be thus directly compared with the results of the investigation conducted in the laboratory of the Museum.

The quantities and nature of the products, as certified by Dr. Hodges, in the one trial which he superintended, compared with the Museum average results reduced to the same standard (Dr. Hodges' acetic acid having been 25 °/ₒ of real) are—

	Professor Hodges.		Museum.	
	From a ton.	From 100 parts.	From a ton.	From 100 parts.
Sulphate of ammonia	22¾lbs.	1·000	24 8/10lbs.	1·110
Acetic acid real hydrated	7¼lbs.	·328	4⅗lbs.	·207
Wood naphtha	83½oz.	·232	50⅕oz.	·140
Tar	99½lbs.	4·440	53¾lbs.	2·390

It hence is evident that the quantity of ammonia obtained at Newtown Crommelin is rather under that obtained at the Museum; but the produce of acetic acid, tar, and naphtha, has been found in average decidedly inferior to that stated, although the maximum results found in particular trials have approximated closely to Dr. Hodges' numerical results. There having been, however, apparently but a single trial so accurately followed up at Newtown Crommelin, it is necessary to contrast the results of the Museum experiments more specially with the quantitative produce expected by Mr. Reece, as given in the prospectus of the company to be formed for working his process.

Mr. Reece's statement of the produce from 100 tons of peat distilled is compared with the average results of the Museum trials in the following table:—

From 100 parts of peat.	Statement in Mr. Reece's prospectus.	Average results of Museum trials by blast process.
Sulphate of ammonia	1·000	1·110
Acetate of lime	·700	·305
Wood naphtha	·185	·140
Paraffine	·104	·125
Fixed oils	·714	1·059
Volatile oils	·357	

From this comparison it is evident that the quantity of ammonia obtained is rather greater than that expected by Mr. Reece; secondly, that the quantity of paraffine and of oils may be considered the same; thirdly, that the quantity of wood-napthha expected by Mr. Reece is more than we obtained in average, but not more than was obtained in some Museum trials. That the quantity of acetate of lime expected by Mr. Reece is more than double that which was in average obtained in the Museum, unless the commercial acetate of lime calculated for by Mr. Reece shall contain such excess of lime, &c., as shall render its weight double that which the pure article, calculated in the result of the Museum trials, should have. This latter circumstance may possibly explain the difference.

It may, therefore, be admitted that the statements made as to the quantities of those bodies obtainable from peat have not been exaggerated, and, indeed, are such as should immediately be inferred to be obtainable from a body of its constitution, compared with coal and wood.

It being thus determined as to the amount of produce, it remains to consider how far the practical circumstances of the operation may influence the feasibility of the manufacture on the great scale. On this subject, so difficult to decide positively, even in the case of a manufacture well understood and practised, when it has been introduced to a new locality, it becomes impossible to arrive at absolute conclusions where the manufacture itself is one of novel character, involving numerous and complex collateral operations, and is proposed to be established in localities and amongst populations unaccustomed to manufacturing industry. I can, therefore, in this report only notice in very general terms some conditions of Mr. Reece's processes, which, as it appears to me, will be found materially to influence the cost of production of the several substances which it is proposed to bring to sale.

Mr. Reece's patent, it will be observed (Appendix, p. 23), is merely for the application of the blast of air to obtain, by distillation, the tarry and gaseous products of the peat. But, as first obtained by distillation, these products are all in a condition excessively impure; and there will be required for their separation and purification special and complex chemical operations. The distillation of the peat must, in fact, be looked upon as only the means of obtaining what are, in reality, the raw materials of a number of chemical manufactures, just as by the distillation of coal there are obtained gas liquor, which forms the basis of a special ammonia manufacture, and gas tar, which gives occasion to naphtha, oil, and pitch making, while these are only collateral or waste products compared with the gas and coke on which alone the managers of gas companies find it worth while to fix their own attention.

These materials, however, obtained as residues of more important manufactures of charcoal and coal gas, must be considered as in themselves having but very inferior commercial values, and the price of the product obtained from them is almost altogether determined by the expence of the subsequent purification and extraction of those products in a commercial form. Hence the value of the process in a manufacturing point of view depends on two conditions—1st, that materials shall be supplied at an extremely low or nominal cost; and 2nd, that there shall be such economy in the processes of manufacture as that the final cost shall be below that of the same products as now made. It is evident that in the distillation of a quantity of peat to obtain tar, ammonia, acetic acid, and naphtha, there must be employed a quantity of fuel, which, by the process of Mr. Reece, is made to be that actually under distillation, which, as it cokes and descends in the furnace, is burned by the blast and supplies the heat necessary for the distillation of the superincumbent layers. Whether actually all the coke requires to be thus burned in each operation cannot be positively asserted until the process shall have been continuously carried on, on the great scale; but it would be, as I believe, imprudent to calculate on any portion of the coke of the distilling furnace being directly available for any other uses, or being a source of independent profit.

The cost, therefore, of the tar and liquors for the subsequent manufacture will be equal to that of the entire quantity of peat employed, together with the cost of erecting, maintaining, and working the distilling and condensing apparatus. The arrangement of these latter will, however, be probably found to require serious consideration; the furnaces being in form and dimensions similar to the high iron furnaces, and being required to constitute, when in action, true gas retorts, air-tight, in order that the products may be blown through the condensing apparatus. It will probably be found that an amount of pressure will be required to be used with the blast machinery that may render its expense a very appreciable item in the cost of production, as it must be recollected that, although the proposed manufacture may be represented as a combination of the arrangements of an iron-works with those of a gas-works, yet it will be observed that the relations of the products are just reversed; the volatile products of the iron furnace being usually waste, whilst in the peat process they are those sought. On the other hand, in gas-works the condensible vapours are little valued, and are condensed only to purify the permanent gas, which is the important product; whilst, in distilling peat, the condensible vapours form the commercial materials, and the gases have no direct value. There is therefore, the grave difference between the condensation in the gas-works and in the peat-works—that in the former, provided the gas will burn without bad smell, the more it is loaded with carbo-hydrogen vapours, and the higher specific gravity it possesses, the more brilliant light it gives and the higher value it possesses. Hence the condensing apparatus may be the minimum that will remove the gross impurities; but in the peat-works, the gases being of no commercial value, and the condensed products being those to be afterwards sold, everything that escapes condensation is a money loss, and the apparatus for effecting condensation will require to be of the most perfect description.

It is quite certain, however, that the condensation can be effected with success by means of suitably extended and cooled apparatus; but, considering that all the products issuing, at a very high temperature, from two furnaces burning together 100 tons of peat every twenty-four hours, and accompanied by a current of at least 200 tons of atmospheric air (the volume of which may be estimated at 215,000 cubic yards), and possibly twice as much, and referring to the difficulties of condensation which were felt even in the experiments on a small scale conducted in this laboratory, and to the circumstance that at Newtown Crommelin the process of distillation went on excessively slowly, being only at the rate of from 1½ to 2 tons of peat per diem in the largest furnace that has been as yet used, it will appear natural to expect that the perfect condensation which should afford, on the great scale, the realization of the entire products may be found to require apparatus of a magnitude very far exceeding anything as yet proposed.

It therefore requires to be considered that, in the peat-distilling process, the materials from which the commercial products are to be obtained will cost the outlay on the peat employed, the charge of erecting, maintaining, and working the furnaces, and of blast-machinery, and of the condensation apparatus; and these materials, when so obtained, are similar to those obtained as residues from wood and coal distilling processes, and available at present, at very low prices, for further manufacturing objects.

Under these circumstances it must evidently be, in great part, by the introduction of improved and more economical modes of treating those new materials, that the manufacture proposed by Mr. Reece can be conducted with practical advantage. These improvements do not form any part of Mr. Reece's patent, nor are any of them of individual novelty. They consist, as far as I have had an opportunity of judging from the communications made by Mr. Reece, and by his answer to queries (Appendix, p. 32), in two points—1st, separative distillation; and 2ndly, in the employment, as fuel, of the gases given off from the furnace. The necessity of the first economy arises from the circumstance that the quantities of acetic acid, of ammonia, and of pyroxylic spirit, obtained by the distillation of peat are diffused through so large a mass of watery liquor, that their separation, after treatment with lime and sulphuric acid, respectively, by the ordinary processes of distillation, would become tedious and expensive. In this respect, however, the adaptation by Mr. Reece of the principle of separative condensation will, as I believe, prove highly useful, and in this respect probably secure the most economical manner of operating that could well be devised. This branch of the operations, however, does not enter into Mr. Reece's patent, being rather connected with the employment of the form of rectifying still, invented and patented by Mr. Coffey, of Dublin, some years ago. It will certainly be, however, questionable, whether this economy, although useful and ingenious, can affect in any very material degree the final result of the manufacture, as it regards only one stage of the preparation of one or two articles, which are not more specially valuable than several others it is proposed to obtain.

The much more important attempt to reduce the cost of extracting from the raw products the several articles proposed in a commercial form, and, indeed, of conducting with economy the actual blast-distillations, consists in the application as fuel of the gases produced in the blast-furnaces by the distillation of the peat; which gases, as they will issue from the extremity of the condensing apparatus, after all the tarry and watery products shall have been condensed, should be made by their combustion to supply the heat required for all the distillations and evaporations necessary in the several branches of the manufacture, and also to heat the boilers for the steam-engines to work the blast-machinery and the other machinery of the works. For this purpose Mr. Reece has kindly explained to me that it is proposed to carry the gases which escape from the extremity of the condensing apparatus into a system of underground flues, which shall ramify, as gas-mains ramify in the streets of a city, to the several localities of the works where furnaces are erected. At the point where each branch-flue opens into its furnace, will be adapted a mechanism for regulating the entrance of the gas; and there being, by means of a chimney of great height, a draft of air established, also regulated by mechanism, so that the combustible gas and air shall bear a proper proportion to each other, the conditions for using the waste gases as fuel should be fully realized in theory.

The employment of such waste gases as fuel had been long since proposed in the case of iron smelting-works, where vast quantities of carbonic oxide and other gases escape from the tops of the high furnaces; and those gases had been in many cases successfully conducted to the hearths of the puddling and refining furnaces, where their flame served to economize a certain quantity of ordinary fuel. Hence the proposition of Mr. Reece, to treat in a similar manner the waste gases of the peat-furnaces, merits full consideration. It is in theory certainly quite possible to effect it. At the same time it must be borne in mind that the economy and practical advantage of the plan has not been found, even in iron smelting-works, so absolute as to produce its universal or even general adoption, and yet in an iron-works the arrangements, are much more simple; the gas conduits would not require the same exact arrangement for supply, and, what is of the greatest importance, the gases are used from an iron furnace very hot, and are found to require to be so used in order to enable them to serve as fuel.

The employment of the waste gases as fuel does not appear to be considered by Mr. Reece, as in the iron works, an accessory and secondary economy, but forms so great an object that, as stated in his prospectus, "in distilling 100 tons of peat a quantity of inflammable gas is obtained, equal in value to 20 tons of coal"—that is to say, of nearly equal heating and money value to the entire body of peat by which it was produced. This, however, could not be the case, even by distillation in close vessels, where all the carbo-hydrogen gases could be economised, and becomes quite impossible where the distillation is carried on by blast, and the carbo-hydrogen and carbonic oxide must issue mixed with the whole volume of nitrogen of the enormous body of air that had been blown in, as well as with the very large quantities of carbonic acid derived from the distillation as well as the combustion of the peat.

But it appears evident that Mr. Reece calculates on effecting all the boiling, evaporating, and distilling operations of the various special manufactures by means of these waste gases only, as there is not found in his estimate any item for cost of fuel, beyond the actual peat that is to be distilled; and in his prospectus it is proposed to employ the gases in even further subsidiary processes, as burning lime, carbonizing peat, &c. It does not appear to me that the successful employment of those gases could be calculated on to so great, if to any great degree, and in the special report there will be found the detailed evidence that the gases issuing from the blast retort where the process of Mr. Reece was carried on, were scarcely and only at times at all inflammable, and could not be in any way depended on for steady combustion, or as a regular supply of heat. There will be found also the details of experiments on the combustibility of mixtures of inflammable gases (carbonic oxide, and carburetted hydrogen) with such volumes of nitrogen as the blast of air should at least supply in Mr. Reece's process, and the result appears to be, that although such mixtures may, by careful management, be set on fire, yet no dependence could be placed upon a current of such gaseous mixture burning continuously, and that a manufacturing process requiring heat should not be left dependent on such a fuel.

It will be remarked that I have here spoken of the combustibility of those gases, as they issue cold from the extremity of a condensing apparatus of a very perfect kind. It is this particular which prevents the success obtained in the employment of similar gases in iron smelting operations from being a fair analogy. The gases are conducted from the body of an iron furnace, strongly heated, by short channels to the flame-beds of other furnaces, and their combustibility is greatly enhanced by—indeed arises from—their high temperature: besides which they are used only as subsidiary to already existing fires, being never, that I am aware, taken as the only fuel on which important operations should be left exclusively to depend.

It is not my wish to enter into any examination of the minute details of the processes of purification and preparation of the commercial substances from the raw products of the manufacture. These processes do not form any portion of Mr. Reece's patent, and the only statement regarding the plans proposed to be pursued is that in the article on Mr. Reece's project published in Mr. Dickens' Journal, 'Household Words,' (January, 1851) which account, however, Mr. Reece has, in his answers to queries, adopted as authentic. There will be found in the description of the experiments some facts regarding the action of sulphuric acid on the tar from peat, and its power of separating the resins, which will render it doubtful whether the process may not be more expensive than Mr. Reece would appear to suppose, and in fact whether other modes there indicated might not be found more advantageously applicable than that proposed to be adopted by Mr. Reece.

In reference also to that process, it may be remarked that as some million of pounds weight of oily and fatty material are to be bleached annually, and that the bleaching is proposed to be effected by means of bichromate of potash, a salt of very high commercial value—no item of the cost of that salt is given in the estimate of outlay, nor is there any notice of its recovery, or of the source, other than ordinary purchase, by which it is to be obtained. Yet, operating on such enormous quantities it should be taken into account, as, if not recovered in some economical manner, it might seriously affect the cost of production of those fatty and oily bodies on which so much of the productiveness of the proposed manufacture depends.

There will be found in the report of special details, the facts regarding the processes for obtaining the paraffine and oils out of the tar, and some suggestions by which methods of greater effect than those described as Mr. Reece's could be employed. The most remarkable result, however, is that the resinous bodies which, in Mr. Reece's processes are separated by means of sulphuric acid, and are rejected as valueless, are themselves capable of conversion into paraffine (so called), and thus the quantity of that solid fatty material obtained from the peat may be rendered much larger than what had been supposed by Mr. Reece to be possible.

I shall not refer to any other circumstances of the cost of purification and bringing to marketable form the products of the distillation, as I do not feel that it would be within my object to discuss the actual money estimates that have been put forward in the prospectus of the Company proposed to be established.

From those considerations of the results of the experiments made in the Museum of Industry, and the trials at Newtown Crommelin, and of the circumstances of the manufacture of the same products from the other species of fuels by processes more or less analogous, it appears to me that some general conclusions may be deduced:—

1. That the quantities of ammonia, of wood spirit, and of so called paraffine, fixed and volatile oils, stated by Mr. Reece to be obtained by distillation from peat, do not appear to be exaggerated, as they fall within the limits of the results obtained in the Museum laboratory, and approach closely to the average results. That the quantity of acetic acid or acetate of lime, stated by Mr. Reece and Dr. Hodges, could not be obtained, the result of the Museum trials affording but from one-half to two-thirds of the expected quantity of that substance. That further the produce of paraffine may possibly be rendered much more considerable than was stated by Mr. Reece, through a more judicious treatment of the resinous materials of the tar than had been proposed by that chemist.
2. That the distillation with combustion of the peat in the blast furnaces must be considered to produce only the raw materials for the subsequent chemical operations, just as in the processes of wood or coal distillations, there are produced tar and ammonia, and acetic acid, which have long been the objects of manufacture.

3. That those materials, if charged with the total cost of the peat consumed, the cost of erecting and working the furnaces, the blast engines, and condensing apparatus, and proportion of management, would not appear to be very much more economically obtained from peat than they are now obtained from the products of wood and coal distillation, where they are sold at very low prices, and, at least as regards gas tar and gas liquor, in most places in Ireland, have been regarded as waste products.
4. That the principal value of the class of products obtained from peat is derived from the cost of their subsequent purification and conversion into a commercial form, and that consequently the principal advantage of a new mode of obtaining them must be looked for in the more economical treatment of those materials.
5. That to this principle the extraction of the paraffine may be an exception, it being itself a material new to commerce on a large scale, and hence not having its value determined by the comparative economy of preparation from sources of little value.
6. That the economies introduced in the treatment of the tarry and watery products of peat distillation are reducible to two (so far as I have been able to learn) :—1, the separation of the wood spirit, by means of an improved distilling apparatus; and 2, the utilization of the waste gases from the condensing pipes, so as to supersede the use of other fuel by burning the gas in jets under the steam boilers, tar and acetic acid stills, evaporating pans, &c.
7. That the former economy cannot be of paramount influence, as it affects but one stage of the preparation of a single product, and further might be applied in a similar way to lessen the cost of production of wood spirit from any other source.
8. That the latter economy is of the most important character, and appears more than any other one condition to influence the probable success of the manufacture on the great scale; that therefore the amount of advantage derived from similar employment of gases in iron-smelting works will deserve careful comparison, and that it will be necessary particularly to take into account the difference of combustibility of gaseous mixtures when very hot, as when from an iron furnace, and when quite cold, as from the condensing apparatus of a peat blast furnace.
9. That under the circumstances of a manufacture presenting so many new and complex processes, which, in analogous branches of industry, it is found convenient to separate and commit to different and individual interests, and that its conditions, as to the supply of peat, require its establishment in localities of but little industrial activity, it can scarcely expected that even as much

economy and advantage should be realized as might be expected after experience of the same process on a working scale and with trained labour.

10. That although the excessive returns stated by the proposers of the manufacture may not be obtained, it is yet probable that, conducted with economy and the attention of individual interests, the difficulties connected with so great complexity of operations would be overcome, and the manufacture be found in practice profitable; and certainly it must be regarded as of very great interest and public utility that a branch of scientific manufacture should be established, specially applicable to promote the industrial progress of Ireland by conferring a commercial value on a material which has hitherto been principally a reproach, and by affording employment of a remunerative and instructive character to our labouring population.

(Signed) ROBERT KANE,
Director of the Museum of Irish Industry.

8th April, 1851.

APPENDIX.

No.
- I. Specification of Mr. Reece's Patent.
- II. Prospectus of proposed Company.
- III. Letter addressed to Professor Hodges, with his Replies to Queries.
- IV. Letter addressed to Mr. Reece, with Mr. Reece's Replies to Queries.
- V. Detailed Description of Processes and Experimental Results, by Sir R. Kane and Dr. William Sullivan.
- VI. Tables of Composition and Descriptions of different varieties of Peat.
- VII. Supplemental Note and Table of previous Experiments.

No. I.

Specification of Mr. Reece's Patent Process.

To Rees Reece, *of London, Chemist, for improvements in treating Peat and obtaining products therefrom.*—[Sealed 23rd January, 1849.]

This invention consists, firstly, in causing peat to be burned in a furnace by the aid of a blast, so as to obtain inflammable gases and tarry and other products from peat; and secondly, in obtaining products from peat termed paraffine and liquid paraffine, by operating on tar or pitchy matter produced from peat.

In Plate IV., fig. 1, is a plan view of two blast-furnaces and apparatus for carrying out the first part of this invention; and fig. 2, is a vertical section of the same. *a*, *a*, are the blast-furnaces, which are lined with cast-iron at the upper part; *b*, (fig. 1,) is a grating or set of fire-bars; and *c*, *c*, are the blast-pipes, for introducing a blast of air beneath each grating *b*: the pressure of the blast of air which the patentee employs, is from two pounds to two pounds and a half on the square inch. Each furnace is provided, at the top, with a cover, which is raised when the furnace is to be charged: this is done at intervals, taking care that the charge does not descend so low as to go out. *d*, *d*, are pipes, leading from the upper part of each furnace, and dipping into water contained in the close trough *e*; and *f* is a pipe, that connects the close trough *e* with a series of pipes *g*, which are immersed in the water contained in the trough *h*, and form the condensing apparatus, for condensing the products from the two furnaces. The gases, on their exit from the condensing apparatus, may be collected for use as fuel or otherwise; and the tarry and other liquid products pass into a suitable receiver. The tarry products may be treated according to the second part of this invention; and the other products may be made available for evolving ammonia, wood-spirit, and other matters, by any of the existing processes. Either hot or cold blast may be employed; but hot blast is preferred to be used when the peat contains much moisture.

The patentee does not confine himself to the blast-furnaces or condensing apparatus above described, as the construction of the same may be varied; nor does he claim the blast-furnace and condensing apparatus separately as new;—the first part of the invention consisting in causing peat to be burned by the aid of blast in a furnace, so as to evolve and collect inflammable gases and tarry and other products from peat.

The second part of the invention consists in obtaining paraffine and liquid paraffine in the following manner:—The patentee takes tar, obtained from peat in the way above described, or by distillation, and, having freed the same from water, he puts it into a still and distils off about half the quantity at as low a temperature as it will come over; he then distils over the residue into a second receiver. The products in the second receiver will consist of paraffine, liquid paraffine, and a small quantity of volatile hydrocarbons. The paraffine is in the state of crystals, which are separated from the liquid paraffine by means of hair or other fine sieves; then the crystals are melted and run into moulds, about two inches deep; and the cakes, thus obtained, are subjected to pressure, in the manner of pressing stearine, in order to separate the more fluid portion therefrom. The hard product is of a dark yellow colour; to remove which, it is distilled, the product received into moulds, and the cakes, so produced, subjected to pressure in hot stearine presses,—the heat being kept down to 100° Fahr.: if the first distillation does not remove the colour, the process is repeated. After decolorization, the paraffine is melted and washed with water and free steam; and the product is exposed for some days to the action of the atmosphere: this product is suitable for making candles. The liquid paraffine is distilled once or oftener, to remove the colour; and it may then be burned in lamps.

The patentee claims, firstly,—Causing peat to be burned in a furnace subjected to a blast, so as to obtain inflammable gases and other products. Secondly,—Obtaining products of peat, which he terms paraffine and liquid paraffine, by operating on tar or pitchy matter, produced from peat as above described.—[*Inrolled July*, 1849.]

No. II.

STATEMENT OF PROSPECTUS OF THE COMPANY PROPOSED TO BE FORMED FOR CARRYING OUT MR. REECE'S PROCESS.

THE raw materials of some of the most important manufactures of the United Kingdom were not known before the present century to possess those properties which chemical science has since discovered in them, and which the manufacturer is now enabled to apply so largely to his own profit and to the use of the public.

Among the most abundant of such materials, Peat was, until lately, considered as mere fuel, rendering the districts occupied by it unfit for agricultural purposes, except at a cost wholly excluding profit: into its *chemical* properties and its commercial capabilities no one thought of inquiring.

But, three or four years ago, Mr. Rees Reece, an enterprising chemist, having had his attention drawn to the circumstance that peat, in course of ignition, gave off large quantites of volatile matters, whose precise natures were unknown, applied himself to their investigation, and after great expense, intense labour, and numerous trials, he succeeded, not only in discovering their exact and proportional characters, but also in bringing to perfection a series of combined inventions, of simple and inexpensive application, by which these elementary matters were evolved in the form of various commercial products, of great value, and of extensive application.

These discoveries and inventions constitute the basis on which this Company seeks to establish its undertaking.

Mr. Reece, by the aid of his newly discovered process, for which he has obtained letters patent, effects the separation of the elementary constituents of the peat, by a process of combustion, the peculiarity of which consists in its being supported by the oxygen of the air acting on the carbon of the peat, without the assistance of extraneous fuel. During this process, a large portion of the hydrogen and other inflammable gases which are evolved is saved from dissipation, and preserved as sources for the production of heat to be applied in completing the after-stages of chemical manipulation, by which the manuafcture of the commercial products is perfected. But beyond the quantities of inflammable matter consumed in these applications, a large amount of gas remains at disposal, for the generation of heat which may be used or applied in other industrial operations. In these arrangements are found the extreme economy of the process of manufacture, which is thereby endued, to a great extent, with a self-sustaining power.

The chemical elements which are thus derived from peat, or "bog earth," are produced by Mr. Reece's process, in a pure marketable, and highly remunerative form. The chief products which have been obtained, are:—

I. *Sulphate of Ammonia.* This salt is principally used in the preparation of muriate of ammonia, or sal-ammoniac; in the manufacture of alum, and in producing the other salts of ammonia, such as the sublimed carbonate used by bakers, and the solution of ammonia, for the purposes of the orchil makers, dyers, &c.—and it is most extensively employed as a manure, for which purposes it commands a high price and an unlimited market. It has been, hitherto, comparatively difficult of attainment. Vegetable matter, when azote is one of the elements, as the gluten of wheat, yields ammonia; coal soot also contains it; but the decomposition of coal, effected during the production of carburetted hydrogen, for the purpose of gas illumination, forms at present the chief source of ammonia, which by combination with sulphuric acid, is converted into sulphate.

II. *Acetate of Lime*, composed of acetic acid and lime, may be formed by dissolving carbonate of lime in the acid; but by Mr. Reece's process it is distilled from the peat. It is a salt extensively used for producing the ferruginous and aluminous liquors used by calico printers, and it is also the source of acetic acid for various other purposes.

III. *Naphtha, or "wood spirit."* This important chemical agent is produced from the peat in great quantities. It is yielded in a pure, colourless, limpid state, resembling in its properties spirits of wine, and differing only in its odour; and from its properties of combining in all proportions with alcohol, æther, petroleum, &c., it is largely used by hatters and varnish makers, in place of spirits of wine, for dissolving the gums and resins used in their respective trades.

IV. *Paraffine.* Little was known of this valuable vegetable product, till a few years since it was determined by several foreign chemists of celebrity to be a "solid carburet of hydrogen." Dr. Christison obtained it from the petroleum of Rangoon, and called it *petrolin;* and Dr. Reichenbach discovered its presence in the products of distilled beech tar. In appearance it is a fatty but rather firm solid; it is wholly inodorous: at a hundred and ten degrees Fahrenheit, it melts into an oily liquid and evaporates without change; it burns with a pure white flame. It is soluble in alcohol, oil of turpentine, naphtha, and the fat oils when heated; and it unites with spermaceti, wax, and most fatty bodies by fusion. It consists of six of carbon and one of hydrogen. These singular properties fit it in a remarkable manner for the manufacture of candles of a high degree of purity, which are found in use to emit no smell, and to give an intense colourless light.

V. *Hydro-carbon Solvent.* This oil, which is of a thin transparent quality, is well adapted for dissolving gum elastic, gutta percha, and various resins, and will, therefore, in all probability, command extensive use in the preparation of cheap varnishes for rendering sail cloths and other textile fabrics impermeable to moisture.

VI. *Fixed Oil.*—This body, in combination with tallow, will obtain general use in lubricating machinery, and, mixed with common oils, it will greatly assist the manufacturer of a cheap lamp oil.

The commercial value of these articles, and the ease with which they may be produced, are calculated to assure the Company of entire success; but beyond the prosperity which must attend its immediate operations, the ultimate effect of the discoveries on which it proceeds must be productive of advantages of even national magnitude. *Ireland possesses in its peat a great source of wealth and profitable employment, and all that is wanted, are capital and science to make the possessions available to the public use.* This conclusion will be manifest when, in connection with Mr. Reece's inventions, the vast extent of the peat formation is considered. The total area of Ireland is twenty millions of acres. The whole area of bog is estimated at two millions eight hundred and thirty thousand acres: nearly one-seventh of the entire surface of the island. With this immense magazine of wealth at command, it is not too much to assume that the peat tracts may become to Ireland, what the great coal mines are to England, or steam power to the English, Scotch, and Welsh manufacturers, sources of industry, wealth, and public enterprize.

In stating the direct results of Mr. Reece's discoveries, allusion has been made to the collateral advantages which will be secured to the Company in the acquisition of fuel power. These will be of great value and importance. During the operations of extracting the paraffine and other products, a surplus quantity of inflammable gas is obtained which is equal in value, as fuel, to 20 tons of coal for every 100 tons of peat. This it is proposed to employ in the production of peat charcoal, for the manufacture of iron, for which, in consequence of its great superiority to the coal used in the smelting districts of England, a constant and great demand exists;—for deodorising animal manures, and for burning lime, which is in large request in almost every locality in Ireland. These gases being under control could also be applied with great advantage to the manufacture of glass, porcelain, and the refining of metals.

In carrying out the views of the British and Irish Peat Company, it is computed that a capital of 10,000*l.* will be adequate to the erection of an establishment, provided with all suitable apparatus for operating on 100 tons of peat daily, or 36,500 tons per annum; and that it will also be sufficient to provide the means of carrying on the current expenses of the manufactory. The remaining portion of the capital would therefore be expended in the establishment of similar works in different parts of the country.

In proof of the correctness of the conclusions on which the promoters of this undertaking found their expectations, they have great pleasure in stating that after a series of carefully conducted experiments, made under the superintendence of several scientific men, the following data as to the probable annual expenditure and produce of the Company's trial works have been arrived at:—

EXPENDITURE.

36,500 tons of peat, at 2*s.* per ton	£3,650
455 tons of Sulphuric Acid, at 7*l.*	3,185
Wear and tear of apparatus, &c.	700
Wages, labour, &c.	2,000
Cost of sending to market, and other incidental charges	2,182
	£11,717

PRODUCE.

365 tons of Sulphate of Ammonia, at 12*l.* per ton	£4,380
255 tons of Acetate of Lime, at 14*l.*	3,570
19,000 gallons Naphtha, at 5*s.*	4,750
109,500 pounds Paraffine, at 1*s.*	5,475
73,000 gallons Volatile Oil, at 1*s.*	3,650
36,000 gallons Fixed Oil, at 1*s.*	1,800
	£23,625

Net profits, Eleven Thousand Nine Hundred and Eight Pounds.

The exclusive use of the various patents has been secured to the Company, and a Royal Charter of Incorporation is in the course of being obtained, which will enable the Company at once to commence operations.

The various collateral advantages before referred to are not taken into account in the foregoing calculation.

It only remains to state, in concluding this announcement, that the most unquestionable testimony, both to the accuracy of the science involved in Mr.

Reece's inventions, and of the facilities attending their practicable application, has been furnished to the Company by M. Pelouse, Member of the Institute of France, Director of the French Mint (in whose laboratory the patentee made his first experiments); Dr. Hodges, Professor of Agriculture, Queen's College, Belfast; Messrs. Coffey and Sons, Engineers, Bromley; and other eminent chemists whose opinions have been taken on the subject. Under the decisive sanction of these practical authorities, the promoters of this Company appeal with confidence to capitalists, to render them support in carrying out the Peat Works, whose ascertained and undoubted returns, while they offer ample remuneration on the acquired investments, will also provide profitable employment to a considerable portion of the unoccupied population of Ireland.

No. III.

Communication from Professor Hodges.

February 7th, 1851.

Points on which Sir Robert Kane requests to be informed by Professor Hodges of Queen's College, Belfast, regarding the result of the Peat distillation carried on at Newtown Crommelin.

1. What were the dimensions and mode of construction of the furnace for distilling?
2. What was the mode of blowing and the dimensions of the blowing apparatus?
3. What was the size and arrangement of the cooling and condensing apparatus?
4. Was there any difficulty felt in the practical management of the condensation?
5. What weight of turf did the furnace contain, and how long did its distillation require?
6. What was the cost of the turf employed per ton, cubic yard, weight, and measure?
7. In what state was the peat put into the distilling furnace? If wet, what was the average per-centage of water: if dried, how and to what point?
8. What was the description of peat employed? Its density? The locality of its source? Its position as to depth from surface, and structure?
9. Was its composition determined? What was its per-centage of ashes, and their composition?
10. In the working of the process, were the turf ashes melted into slags? Could they be run out liquid from bottom of furnace at end of process?
11. Was the process carried on continuously by adding from time to time fresh quantities of peat, or was the operation interrupted by one charge being burned out before another was introduced.
12. How frequently did the interior of the furnace require renewal or repair?

13. Were the condensing pipes or vessels attacked, or in any degree corroded, during the process?
14. What was the total quantity of turf worked upon in the apparatus whilst the works were in operation?
15. What were the quantities of the tarry, watery, and gaseous, products obtained?
16. What was understood to be the cause of the discontinuance of the works at Newtown Crommelin?

DEAR SIR ROBERT, Belfast, Feb. 20, 1851.

I return you the list of queries, to which I have given as full replies as I am able. If you desire any additional information I shall endeavour to furnish it. I delayed for some days replying to your letter that I might ascertain from a friend who lives near Newtown Crommelin, and who watched the progress of the works, the actual amount of peat consumed. I think it probable that you may have been induced from the newspaper reports to imagine that an extensive manufacture of the products for commercial purposes had been carried on. Such, however, was not the case: only experimental trials were made. I was sorry to observe a good deal of exaggeration in the statements published in the London papers, seemingly by authority. Still I think the speculation is one you would be warranted in recommending, though I would certainly prefer seeing it carried forward by individual effort. You will perceive that I know nothing accurately of the results, except so far as relates to the products obtained in my own experiments. Mr. Reece consumed nearly two years, working at intervals, and making, I believe, but little real progress. I send you a specimen of a candle which was forwarded to me by Mr. Owen. I believe it contains some wax, but how much is not stated.

The process employed in the separation of the paraffine from the crude tar was first to mix the tar with four per cent. sulphuric acid; to add water, and after the subsidence of the impurities, to draw off the liquid with the oils, etc., mixed with it. The liquid upon distillation affords in the first part of the process the hydro-carbon, and towards the end of the operation the paraffine and dense oil. Upon allowing the mixture of oil and paraffine to cool, the paraffine separates in flakes. The next operation is to separate the two bodies, which is effected by pressure, the solid paraffine remaining in the bags while the oil escapes. To purify and discolorize the paraffine, Watts's chromic acid process is employed. Re-distillation is also practised, which increases the transparency of the product, and the action of currents of steam has also, I am informed, been tried with good results in still further improving its appearance.

The oils do not evolve any marked odour of sulphuret of carbon. They are, however, at first of a bad colour and smell; the smell, I think, depends chiefly upon the presence of some capnomore. The oil is purified by a somewhat similar process to that adopted for the paraffine.

Yours, &c.,

Sir R. Kane. JOHN F. HODGES.

REPLIES TO QUERIES.

1. The furnace employed consisted of an iron cylinder imbedded in an erection of mason work, about 17 feet in height. The height of the cylinder was about 15 feet: its diameter 3 feet. About 2 feet from the ground furnace bars were placed which formed the bottom of the cylinder. Below the bars there was an ash pit provided with a door which was closed during the experiment. The lower part of the iron cylinder was lined with fire-bricks so as gradually to reduce its diameter from 3 feet to 18 inches. Directly above the furnace bars the pipe of the blowing apparatus entered, and near the top of the cylinder a pipe about 9 inches in diameter was fixed, which was connected with the condenser. I may mention that the casing of brick within the cylinder was not used in all the trials, but found convenient for supporting the mass of peat. It was, I think, continued for about 9 feet above the bars. The cylinder was closed at the top by a strong plate of iron in which was fixed a small door, through which to supply the turf.
2. I am unable to state the dimensions of the blowing apparatus. The cylinder of the pump was, I think, about a foot in diameter. It was an old and very inefficient machine, and was worked by a small water wheel. It supplied merely an intermittent blast of no great power which was directed by means of pipes to the lower part of the cylinder. There was nothing peculiar in its construction. A hot blast might advantageously be substituted when wet turf is employed.
3. I can only speak from memory with respect to the size of the condensing apparatus which was of the same form used in pyroligneous acid works of which you have given a drawing in your 'Elements.' It was, in fact, a large Leibig's condenser, consisting of a double coil of iron pipes about 80 feet long. The outer casing was formed of thin sheet iron, and had a diameter of about 9 inches. A stream of water from a mill-race was made to flow between the inner tube and its case.
4. There was some difficulty occasionally found in the practical management of the condensation. The pipes sometimes choked a little. There was, however, an opening about 20 feet from the end of the coil which enabled the workmen to clean them out. Straight pipes might, I think, be advantageously substituted for the coil.
5. The cylinder was capable of containing about a ton and a half of the ordinary peat. The usual weight of the peat was 6 cwt. per cubic yard. The duration of the combustion depends upon the power of the blast. In my experiment I found that much slower combustion than Mr. Reece had before that time adopted increased the produce. I occupied three days in burning 2 tons of peat.
6. In the district where the experiments were made the cost of the turf would not exceed 2*s*. per ton. The weight of black mountain turf may be taken at from 5½ to 6½ cwt. the cubic yard or "gauge."
7. The turf used had been put up in stacks for house use.

8. The turf employed was the black unctuous kind common in the glens of Antrim, weighing as above stated (6) about 6 cwt. per gauge.
9. The following is the composition of a sample of peat from the district:—

100 grains contained—

Water and Volatile Matter	70·15
Charcoal	24·50
Ashes	5·35
	100·00

The turf used in the experiment contained only 3 per cent. of red coloured ash.

10. Occasionally the ash melted and ran out in a liquid state through the furnace bars; but in the greater number of cases a considerable quantity of light, powdery ash was collected.
11. The process was carried on continuously by adding fresh quantities of peat, when the furnace had burned down about three or four feet. It is considered important to retain in the cylinder a constant quantity of carbonized matter.
12. I am unable to say what the wear and tear would be in the large scale, as but a small amount of work was done. I did not observe any marks of injury in the cylinder, etc., and I am informed that it did not require any repairs while in use.
13. I did not observe any marks of corrosion, nor do I think that any great injury would be done to the pipes by the products.
14. The experiment which I conducted, consumed two tons of peat. It was one of a series which had been made at various intervals during the last two years. I have been informed that altogether not more than 50 tons of peat were consumed.
15. The produce which I obtained in my experiment was per ton as follows—

Tar	99·5 lbs.
Spirit	5·21 „
Acetic Acid, containing 25 per cent.	28·8 „
Sulphate of Ammonia	22·8 „

The watery liquid, deducting the tar collected in the receiver, amounted to 90 gallons per ton of peat consumed.

16. No attempt was made to carry on the manufacture on a commercial scale. The apparatus provided was very rude, and I am certain that the produce obtained was not the full amount which might be expected.

Sir Robt. Kane, M.D.,
President, &c.

JOHN F. HODGES, M.D.

No. IV.

COMMUNICATION FROM MR. REECE.

SIR,

BEING about preparing, by the direction of the Right Honourable the Chief Commissioner of Woods, a report on the process and products of the distillation of peat, and having for that object been occupied by the necessary investigations in the Museum of Irish Industry, I should be glad, before finally terminating the report, to know whether you would wish to communicate any information on those points which have reference to the special circumstances of your experiments on the same subject. I enclose a list of points suggested for explanation, and I beg to state that I would propose to insert in the appendix to my report such explanation as you may wish to afford, but should of course refer to its purport in the body of the report when such should be necessary.

As I am anxious not to delay the presentation of my report, I shall feel obliged in being favoured with any observations you may wish to make at your earliest convenience.

I am, &c.,

Rees Reece, Esq. ROBERT KANE.

MEMORANDUM.

Points suggested on which Mr. Rees Reece's explanation is invited.

1. Were these experiments made on a large scale elsewhere than at Newtown Crommelin in the north of Ireland.
2. If so, where, at what time, on what quantities, and where have details of the results been published?
3. If such detailed results have not yet been made known, could they be now supplied?
4. During what time and on what quantities of peat were the experiments at Newtown Crommelin made?
5. How many experiments were made at Newtown Crommelin, how much peat was used in each experiment, and how long did each experiment last?
6. Has Mr. Reece any other patent for obtaining products from peat than that sealed 23 January, 1849.
7. Has Mr. Reece any patent referring to the modes of rectifying or separating the products.
8. Is the statement in Dickens' 'Household Words,' January 4, 1851, of the mode of treatment of the products, authentic; and would Mr. Reece wish to supply any further information regarding the methods he now proposes to follow?
9. Has any special form of apparatus been arranged or proposed for the distillation and evaporation necessary in preparing the final products in a commercial form?

10. Has any special arrangement been proposed for economizing heat by applying the waste gases of the furnaces to the subsequent processes? Has Mr. Reece included any such proposal in any of his patents?
11. Mr. Reece is invited to give such explanation as he may wish of the form, nature, and magnitude of the evaporating and rectifying apparatus.
12. In the prospectus of the peat company, and in Professor Brand's lecture, as also in the statement given by the 'Times,' it is assumed that two furnaces of 10 feet diameter each are to distil 100 tons of peat every 24 hours. Mr. Reece is invited to state if any furnace of that size has been built, and what was the condensing apparatus proposed to be adapted to the furnaces of that size.
13. Mr. Reece is invited to send to the Museum of Irish Industry a set of specimens of the products he obtains in their commercial form, for comparison with those obtained in the Museum laboratory, and for exhibition in the collections of the fuel department.
14. Mr. Reece is invited to supply information on any points connected with the subject, not referred to in this memorandum, but on which he may wish to offer any remark.

(Signed) ROBERT KANE.

Phillipstown, King's County,
March 15th, 1851.

DEAR SIR ROBERT,

I BEG to acknowledge the receipt of your letter, enclosing a memorandum of questions on peat; I shall be most happy to comply with your request. I will in the course of a post or two write out the answers; some of my notes I have not with me, but, however, I think I have all you require. The article in Dickens may be considered as authentic, and being a description of a factory about to be erected on the Bog of Allen; I have with me also a drawing of all the apparatus, and when I come to Dublin, I shall cause tracings of them to be made for you. Any other questions you may require, addressed to me P. O. Dublin, will be attended to, and

I am, &c.,

Sir R. Kane. REES REECE.

P.S. Continental peats differ very essentially from the Irish in containing no acetic acid.

DEAR SIR ROBERT, Phillipstown, March 19th, 1851.

I ENCLOSE the answers to your questions; I think they embrace all you requested. My occupations here have not permitted me to write them with more care, or arrange them more suitably for your purpose. Any use you may make of them, of course they are yours. I thought it would be best to send them thus than to detain you in the publication of your report; I shall be happy to furnish any other information or details you may require. Should you wish to have drawings of the various instruments, I shall be glad to furnish them: possibly, a ground-plan of a factory would be interesting, and give an idea of the process better than any description; I hope to be in Dublin next week, and any letter addressed to me there, P. O., will receive my earliest attention. I intend in the course of this year, if I have time, to publish *in extenso* the whole I have done, and the facts which I have collected on the subject.

I am, &c.,
Rees Reece.

The experiments made on the distillation of peat according to the process patented by me in January 1849, were I may say almost exclusively carried out at Newtown Crommelin in Antrim, my previous experiments having been made on peats in France, and by distillation in close vessels. The results of the experiments made in France may be thus briefly stated: they were conducted in cylinders 3 feet diameter and 5 feet long; a charge was effected in 18 hours; the experiments were made on a bog about 18 leagues from Paris, at Pont St. Maxence, where peat was largely charred for the Paris market. I made experiments there also on peats brought from the Vallée de la Somme, the Marais de St. Goud in Champaigne, and from various other districts; the peat at Pont St. Maxence, and also of the other localities was what they term in France, la Tourbe Moulée, and which consisted of the ordinary bog being made into bricks nearly in the same manner as bricks are made. The wet bog was cast in blocks of 4 inches by 8, and when well dried would weigh at Pont St. Maxence fully 400 grammes, and the bogs of the Vallée de la Somme made in the same manner would only weigh 300 to 350 grammes; three men and a boy, and three women would cut bricks and spread 15,000 in a day; a cubic metre (35 cubic feet) weighs 8 cwt. to half a ton, and contained from 10 to 12 per cent. of ash, which consisted of sulphate of lime and alumina, the average result of a variety of experiments is on 100 parts as follows:—

Charcoal	35·04
Condensible products	37·07
Gas by difference	27·26
Sulphate of ammonia	2·44
Acetic acid, not a trace.	
Methylic alcohol 100 on G. Lussac's instrument at the rate of 25 gallons per 100 tons	
Tar	3 to 4·31

I cannot state exactly what quantity of peat was used in making these experiments, but some hundreds of tons was used, for one experiment was made on 25 tons. I did not here make quantitative experiments on the products of the tar.

The experiments made at Newtown Crommelin, by what I shall for convenience term blast distillation, were carried on during some time, and on various quantities, probably in all 200 tons. The furnace at Newtown Crommelin is a cylinder 3 feet diameter and 15 feet deep, the interior of it at the bottom is lined with brick, and which reduces its diameter to 18 inches for 6 feet of the interior; it is capable of holding 70 cubic feet of turf. This furnace has a blowing cylinder connected to it 4 feet stroke, double action, and 2 feet in diameter, and is capable of being worked 20 strokes per minute, power being given to it by a water-wheel. The refrigerator has 206 feet of cooling surface, and which is cooled by means of a constant stream of water. The experiments were made on quantities from 1½ tons to 10 or 20 tons at a time, and the result of all these experiments has fully demonstrated the following facts: first, a furnace presenting an area of 1½ foot immediately above the tuyeres is capable of distilling, and in the most complete manner, 1 ton of peat per 24 hours, and that the products of the distillation from the same peat are uniform in composition.

Secondly, that when two tons are distilled in the same furnace, the products are also uniform, but the distillation is incomplete; and when three tons are distilled, the same is equally true, but a still more imperfect distillation; and when the quantity of peat distilled amounts to one ton or 15 cwt. per hour (from the same furnace), the products are next to nil.

EXPERIMENTS.—*Quantities calculated per ton.*

	Per Ton.
No. 1.—3606 lbs. peat in 24 hours:—	
Sulphate of ammonia	23¾ lbs.
Acetic acid 25 per cent.	26 lb.
Tar	70 lb.
No. 2.—42 cwts., time 24 hours:—	
Liquor 40 per cent.	
Sulphate of ammonia	25½ lbs.
Acetic acid	28
Tar	70
No. 3.—Burning 2 tons in 24 hours; Peat 4806 lbs.:—	
Sulphate of ammonia	17½ lbs.
Acid, acetic	20
Tar	40
No. 4.—2 tons 24 hours; 2 tons exactly used:—	
Sulphate of ammonia	16 lbs. 2 oz.
Acetic acid	18
Tar	42
No. 5.—3 tons, 24 hours:—	
Sulphate of ammonia	12 lbs.
Acetic acid	12
Tar	22
No. 6.—9 tons in 12 hours:—	
Tar	2 lbs.

Ammonia and acetic acid scarcely appreciable.

I have given these six experiments in order to illustrate the theory of the process, and they are only a few out of a vast number that were made; and I may here observe, that, as a general rule, I experimented on 40 cwt. at a time, and the peats used were those in ordinary use in the country: they weighed 5 cwt. per cube yard; I do not mean a cube yard closely packed, but such as you would fill it by merely emptying into. They contained from 1·75 to 4 per cent. of ash, which was principally alumine, oxyde iron and sulph. lime, and silica. I must also state that the gases given off presented anomalies equally great; and when, as in the first and second experiments, there was a mass of carbon above the tuyeres, the oxygen of the air was completely converted into *carbonic oxide*, and scarcely a trace of carbonic acid given out. I have also to observe that the quantity of wood spirit, but not so great a degree, varied; and I may add that peat giving acetic acid and ammonia, when distilled with care, at first, and for some time, the product is acid, and one half of the aqueous product may be distilled, and the liquor remain acid, provided the temperature remain low enough; and pure carbonate of ammonia is, I may say, almost given out at the end of the process only. This is true of close distillation also. I have no patent besides the one sealed January 23, 1849, that extends to Scotland, Ireland, and the colonies; and also I have them for foreign countries; nor have I any patents referring to modes of purification. The article in Dickens' 'Household Words,' January 4, 1851, is authentic; and a description of a plant, capable of working 100 tons daily, and consider that to be as detailed and correct as perhaps it would be possible to furnish, excepting I were to enter into forms of apparatus, and in that case it would require drawings and voluminous descriptions, which might possibly be foreign to a report; nevertheless, I shall feel happy in furnishing them. The distillatory apparatus which I use for throwing off the ammonia and naphtha from the rough liquors, is a modification of A. Coffey's distillating apparatus, which has been so successfully used in distilling grain wash in these islands. I use the analyzing part of his apparatus, but I increase considerably the number of plates, and as you multiply the number of plates, the more concentrated is the distillate; and also by the apparatus this whole of the ammonia is distilled, for the liquor will scarcely show indications of it by *litmus*. I rectify the naphtha either by a similar apparatus, or by blowing *steam* into a close safe with a set of cups attached to it for rectifying it at once. In evaporating down the *spent wash*, of the distillating apparatus, and which consists of acetate of lime, I *boil down* in large evaporating pans. Now, as it is well known that 1 foot of surface will only evaporate 1 gallon of water per hour, and if 100 tons of peat be used per 24 hours, I will have 500 gallons or 600 per hour to evaporate, which would require two evaporating pans of 30 feet by 10; but instead of theoretic quantities, I have four such pans set. These pans are made either of cast-iron or boiler plate. The sulphate of ammonia is crystallized in leaden vessels, and boiled down also in lead.

The fuel necessary for carrying on all the various processes—such as driving the steam engines for working the blowing machine, and also firing the various boilers, evaporating pans, tar stills, &c. &c., is the gas resulting from the distillation, and the quantity necessary for every 100 tons of peat used is 2,000,000 cubic feet, leaving 4,200,000 cubic feet for other purposes. I have no patents as to mode of application, but what I propose is, to send them by means of flues to the *various fires*, and effect the draught by a powerful stack, and when a diffuse flame is required, such as for evaporation, I send a *broad sheet*, and when the heat is required to be localized, I send it in jets well mixed with the air. I did not consider these things worth while patenting. The 4,200,000 feet of inflammable gas in excess, I hope to use as fuel for various purposes, such as burning lime, brick baking, and I hope glass making, for which these gases are so well fitted. I may as well state that this quantity of gas is capable of making 60 tons of lime.

The statement in the prospectus of the Company, and in Brande's lecture, also in the 'Times' paper, assumes the burning of 100 tons of peat by two furnaces, 10 feet diameter each, *at the boshes*. The refrigerators attached to them have given me great trouble and difficulty; the law on the cooling of gases established by *Newton*, and which has been so elaborately studied by Dulory and Petit, is I fear inaccurate; but, however, from the results of my own experiments, made expressly for the purpose, and also the experience of various gas engineers in London, and elsewhere, has led me to the conclusion that 12,000 feet of surface will be fully sufficient to completely refrigerate the whole 6,200,000 feet of gas. The form of this enormous *worm* will depend on the locality in which it is placed, and the number of feet of surface exposed will depend on the former to some extent.

As the tar produced from peat is solid at ordinary temperatures, the worm must be so arranged as to admit of being cleaned with great facility; in order to do that effectually the refrigerator is arranged as a double one, so that one part of it may be thrown out of action for cleaning, or other purposes, without stopping the work: this is effected by means of *throtle valves* at the hydraulic main, and stuffing-boxes at each bend. It is also indispensable for the successful working of this process, that two furnaces be erected and in action at the same time, for if one furnace were at work, and an accident to happen to it, the whole establishment would be stopped, for not only do the furnaces furnish the products of distillation, but also the fuel for all the subsequent processes. No large furnaces of 10 feet diameter have as yet been erected, but I am making arrangements at present to erect two such for this Company.

In my experiments on the tar of peat, I think the article in Dickens sufficiently detailed for all practical purposes. My experiments were generally conducted on quantities from 10 to 90 gallons at a time, and the results per cent. are almost uniformly the same. The apparatus which I am about to fit up will be heated by heated steam, by which the quantity of paraffine will be very much increased: I have called the body paraffine, though it differs very materially from that described by Reichenbach. Nevertheless, I consider these bodies on general terms to be so similar, as not to be worth a new name. I shall be happy to send to the Museum of Irish Industry specimens of all I have made from peat. An ordinary peat bog, such as the bog of Allen, and when undrained, only contains 16 per cent. of dry peat—I mean ordinary fuel, and in some cases it is as low as 10 per cent.; and if the bog be well drained, 20 per cent. of dry peat. This peat, in its ordinary state of dryness, and kept in stacks for twelve months, will yield 40 per cent. of its weight of condensable matter by destructive distillation; therefore, to get 16 tons of peat on the bog of Allen, in its present state, requires 100 tons of bog, and 84 tons of water to be evaporated. I think these facts fully demonstrate that no artificial means can ever be employed to harvest peat; and in reflecting on the various processes that have been proposed for that purpose, how little must the parties have studied the subject: doubtless the best of these is that proposed by Mr. Rogers, which may be said to be a brick machine, with compressing power given from an oscillating beam; and probably the most absurd, the turf kiln of Mr. R. Mallet, Ph.D. I have seen some of them on the bog of Allen, one about three miles from *Monastereven;* to suppose that any artificial means of applying peat to evaporate 80 or 84 tons of water, to get 20 or 16 tons of peat, must suppose an arrangement of physical chemistry unknown at present. I may further state that one acre statute on the bog of Allen, on an average, contains 4000 tons of peat in its dry state.

March 19*th*, 1851. (Signed) REES REECE.

NO. V.

Supplemental Report of the details of the chemical analysis of the varieties of Peat, and of the methods and results of the experiments on the distillation of Peat in close vessels, and in air blast furnaces.—By Sir ROBERT KANE *and Dr.* W. SULLIVAN.

The subject of the following report naturally divides itself into two parts:— 1st, the general constitution of the parts examined; and 2nd, the nature and proportion of the products obtained by their distillation, and in this order we shall treat the subject. We have avoided as much as possible the consideration of theoretical questions, except where indispensably necessary, as we hope in a short time to be able to return to the subject, with the view of availing ourselves of the great facilities which Ireland presents for the study of this difficult, but exceedingly important subject; the elucidation of which is equally important in geology and in agriculture, as in explaining the complex metamorphosis of vegetable matter.

PART I.

All the specimens of peat examined, were either from the great bog of Allen, or from its prolongation beyond the Shannon. This tract, however, includes fully two-thirds of all the important turf bogs in Ireland, and as the localities selected are pretty evenly distributed over this great district, the results which we have obtained may be considered to represent very well the constitution and products obtainable from any ordinary specimen of peat. It is, however, necessary to remark, that the greater number of specimens examined were from that part of the bog where the upper layers of *fibrous* or *red bog* peat, composed principally of sphagnum obtusifolium, and squarrosum, mnium palustre, hypnum palustre, and other mosses, begin to pass into dark brown or black compact peat; or were from the surface layer of a *compact peat* bog, upon which no true fibrous or red bog peat had as yet formed, being in fact that kind of peat principally used as fuel. But, as will be seen, on reference to Table I., several specimens of the true red fibrous peat, and also several of the black compact peat, from the lowest layers of the bog, were also examined. We regret that we had not an opportunity of examining each successive layer of the same bog, and also a specimen of a mountain turf, into the composition of which mosses enter but in a very small proportion, if we except probably the *hypnum lanuginosum*. Judging, however, from the results obtained from the examination of some peats, rich in remains of grasses, carex, juncus, and of heath, and which thus resembled true mountain peat, we do not think that the latter would present any considerable deviations from the proportions given in the tables following.

Considerable differences existed between the proportions of water in the varieties of peat examined, a circumstance which is easily accounted for by the difference of compactness, and by the length of time the turfs had been cut. Indeed, it would be difficult to find two bricks of the same turf having absolutely the same composition, but especially the same percentage of water; the limits of this variation are, however, exceedingly narrow.

ANALYSIS OF PEAT.

Having selected the specimens, our first care was to obtain a portion of each which would represent, as nearly as possible, its average composition. For this purpose, a number of bricks were carefully selected, representing the various degrees of compactness and shades of colour, and weighing together about fourteen pounds. These were reduced to a moderately fine powder in a mortar, well mixed together, divided into four parts, one of which was selected and reduced to an impalpable powder, which was thoroughly mixed and preserved in well corked bottles. From this mass all the determinations were made.

Preparation of the Ash.—The peat was first charred in clean Hessian crucibles, and the incineration completed in Berlin porcelain ones. When completely burned, it was placed in a well-corked bottle, having been first rubbed in a mortar in order to mix the ash prepared at different times.

Analysis of Ash.—Determination of Hydrochloric Acid and Alkalies.—From twenty to fifty grains of the ash were boiled with water, poured on a filter, and the insoluble residue washed with boiling water until a drop of the filtrate, rendered slightly acid by nitric acid ceased to give a precipitate with nitrate of silver. The filtered solution was then treated with a little nitric acid, and the hydrochloric acid precipitated with nitrate of silver. The liquid separated from the chloride of silver was then evaporated to dryness with sulphuric acid, the excess of silver having been first removed by means of hydrochloric acid. The dried sulphates were then dissolved in water, and the potash and soda determined by Liebig's method with acetate of barytes. The potash and soda were not separated, except in two instances, the more accurate means of the "Indirect Method" having been employed in all the other cases.

Determination of the remaining Ingredients.— From twenty to fifty grains of the ash were boiled with strong hydrochloric acid, filtered, and the insoluble residue washed with boiling water as long as a few drops of the filtered liquid evaporated to dryness on a platinum knife left a residue.

a. *The Insoluble Residue.*—The residue thus washed, and which consisted for the most part of silicious sand, and occasionally a little undecomposed clay, derived from the subjacent clay or surrounding gravel beds, was dried, ignited, and weighed. Having, however, observed that when soil and other substances, rich in silica, are boiled with hydrochloric acid, the whole of the silica set free from its combinations is not held in solution by the acid, but is in part to be found mixed up with the undecomposed residue, we treated this weighed residue for a few moments, at a boiling temperature, with a weak solution of potash, allowed the liquid to rest for several hours, then decanted it off, and washed the residue several times. The entire decanted liquors were then treated with hydrochloric acid, to neutralize the potash, and evaporated to dryness, heated a few degrees above 212° Fahr., moistened when cold with one or two drops of hydrochloric acid, boiled with water, and the silica collected on a filter, washed, dried, ignited, and weighed. The weight thus obtained, subtracted from the weight of the residue, gives its true weight.

b. *The Solution filtered from the Insoluble Residue.*—The solution was evaporated to dryness, heated a few degrees above 212° Fahr., allowed to cool, moistened with hydrochloric acid, boiled with water, and the silica separated, collected on a filter, washed, dried, ignited, and weighed. Its weight, added to that of the portion dissolved out of the insoluble residue, gives the total weight of silica. The large quantity of sulphate of lime contained in all peat-ashes renders the analysis exceedingly difficult, owing to the large quantity of liquid which must be employed to retain the sulphate in solution, and wash the last traces out of the filters. Great care must therefore be observed in the determination of the silica, as a *very* small amount of the sulphate remaining in the filter would have the effect of even doubling its percentage.

The solution filtered from the silica was then treated with chloride of barium, the sulphate of barytes collected on a filter, washed, dried, ignited, and weighed.

Determination of Phosphoric Acid.—The solution filtered from the sulphate of baryta was treated according to the method recommended by Fresenius, by boiling with sulphite of soda and caustic soda, by which the phosphate of alumina, if present, is separated from the phosphate of iron, and the alumina at the same time determined. The liquid filtered from the phosphate of iron precipitate obtained by this method was treated with ammonia, and then precipitated, while nearly boiling, with sulphuret of ammonium, filtered quickly, and the precipitate, consisting of protosulphuret of iron with traces of manganese, washed uninterruptedly with boiling water, and the lime in the solution determined by oxalate of ammonia, and, after the removal of the oxalate of lime, the magnesia thrown down by phosphate of soda. The sulphuret of iron thrown down as above was dissolved in hydrochloric acid, and the iron held in solution by the tartaric acid and ammonia, after the precipitation of the phosphate of magnesia, having been similarly precipitated by sulphuret of ammonium, added, the whole was oxidized with chlorate of potash, and the peroxide of iron determined in the usual way.

The amount of carbonic acid given in the tables of results is not sufficient to saturate all the bases uncombined with other acids. This is accounted for by the greater part of the carbonate of lime having parted with its carbonic acid during incineration, and its having been found more convenient and accurate to treat the prepared ash directly with acid and water, than to first moisten it with carbonate of ammonia, in order to neutralize the caustic lime. Peat ash treated in this way always loses a small portion of its chlorine and sulphuric acid, and we may also add that it is exceedingly difficult to remove the last traces of ammonia, without again driving off a small quantity of carbonic acid.

We have given above but a mere outline of the process of analysis followed by us, but as it does not essentially differ from that usually adopted, we have thought it unnecessary to do more than merely indicate the general nature of the method.

The principal features of importance presented by turf ashes, and which may be at once recognised by referring to the annexed table of results, are: 1, the small quantity of alkalies—the chlorine present being in general sufficient to neutralize the whole of the potash and soda found; 2, the large quantity of sulphate and carbonate of lime; 3, the unusually large quantity of phosphoric acid and of magnesia. All the peat ashes examined have very nearly the same composition, if we leave the carbonate of lime and part of the sulphate and of the iron out of consideration, these being precisely the ingredients which are, at least in part, derived from the soil. During the growth of the peat the soluble salts must all have been washed away, but the turf from bogs, where the drainage from the upper layers is imperfect, must still contain a large amount of soluble salts, so that in this respect there must be some difference observable between different peats, and even between different parts of the same bog. The existence of a large quantity of phosphoric acid in peat ashes agrees perfectly with the analyses of L. Svanberg of a number of bog iron ores. He found,* for instance, in one specimen 1·28 per cent., and in most instances the quantity varied from a quarter to one per cent. As the object of this report is entirely of a technical character, it would be foreign to it therefore to dwell further on this subject, and we shall consequently defer to another time the consideration of a great number of interesting points connected with the inorganic constituents of peat, and of soils generally.

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* Ber. Jahrb. xix. 322.

ORGANIC ANALYSIS.

The amount of water was determined in the usual manner in a Liebig's drying tube, and the dried peat thus obtained was employed for the determination of the nitrogen, and carbon, and hydrogen. We did not think it necessary to determine the carbon and hydrogen of all the specimens, as the six varieties subjected to distillation represented very well the entire series. But as ammonia forms one of the most important elements obtained from turf, and as, with the exception of one by the Prince of Salm-Horstmar,* we are not acquainted with any previous determination of nitrogen in peat, we made a complete series of accurate analyses by the method of Will and Varrentrap of the entire series of peats which came under our observation. The results of these analyses will, we hope, possess not only a technical but a scientific value; for the present, however, we shall restrict ourselves to the former.

The determinations of carbon and hydrogen were all made with oxide of copper—chlorate of potash being also put into the end of the tube. The great difficulties attending the perfect combustion of peat and similar bodies led us to adopt a modification of the ordinary process, which was found to answer admirably. This modification consisted merely in using a very long tube, about four inches of which, at the end near the cork, was filled with copper turnings which had been heated to redness in a stream of oxygen gas, and had thus the entire of their surface oxidized; between these and the cork was placed about two inches of clean copper turnings, which had been heated to redness in a stream of hydrogen gas whenever the substance contained nitrogen; the mixture was made in the usual way. When the combustion had commenced, the part of the tube containing the turnings was brought to a full red heat, and kept at that temperature until the end of the operation. A large surface of red-hot oxide of copper was thus presented to any unconsumed carbo-hydrogen which may have escaped from the other parts of the tube. The most refractory substances may be readily burned in this way.

The determination of the ash was made in the usual way in Berlin porcelain crucibles; and of the coke or charcoal by heating, to full redness, a portion of the powdered peat already mentioned in a well covered platinum crucible until all fumes had ceased. If the peat be charred in fragments, especially if they be large, the percentage of charcoal will be smaller, as the external portion will be charred before the internal parts become heated, the consequence of which is that the vapours given off by the latter will burn off a portion of the external layer, and thus reduce the amount of charcoal. It is in fact the same result which takes place whenever steam passes over the surface of heated charcoal.

We have now described all the methods of analysis which we employed, in so far as they require explanation, and for the results of the analyses we must refer to the tables in which we have arranged them. The only fact of importance which may be deduced from these results, without entering into theoretical considerations—and it is in fact the principal one which we have to deal with at present—is that commercially speaking, all the peats which we have examined, apart from their physical qualities of compactness, &c., have nearly the same composition. Deferring to another occasion the discussion of these results, we shall now proceed to the consideration of the second part of our subject.

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* W. F. Fürst zu Salm-Horsmar obtained from 0·299 grmms. of turf from Coesfeld 0·024 grmms. of ammonia-chloride of platinum = 0·0063 grmms of nitrogen = 2·100 per cent.—Poggend, 'Annal. d. Phys.' LIII. 624.

PART II.—DISTILLATION OF PEAT IN CLOSE VESSELS.

The nature of the products of distillation of peat, although generally resembling those of most bodies of vegetable origin, have not hitherto been very carefully examined, and indeed we may add that a good deal of confusion still exists as to the nature of the dry distillation of vegetable matter. The products of this distillation are of four kinds :—1, Charcoal; 2, Water; 3, Tar; and 4, Gas. The water, tar, and gas, are exceedingly complex mixtures of substances, the number of which is continually being added to; but as many of those bodies are of no economic value, and form but a small portion of the entire products, we shall leave them out of consideration, and attend only to those which occur in sufficient quantities to be of economical value. These are as follows :—

In the Water.—Ammonia.
Acetic acid.
Pyroxylic spirit, or naphtha.

In the Tar.—Paraffine or some analogous body.
Liquid carbo-hydrogens—differing in boiling point and specific gravity.

In the Gas.—Olefiant gas, marsh gas, and other gaseous carbo-hydrogens.

Whenever wood, turf, lignite, &c., are distilled, all these products are invariably obtained, but their relative proportions differ for each substance. Bodies which contain a great deal of oxygen and hydrogen, especially when in the proportion to form water, give rise to a great quantity of products rich in these substances: such as acetic acid, wood spirit, &c. In this case the products contained in the water are the most important. If the substance contains but little oxygen, such as coal, the products which will predominate will naturally be rich in carbon and hydrogen, and hence we may expect to find in this case the tar an extremely important product. But there is frequently a great difference in this respect between different varieties of the same substance, as for instance, between coals and peats from different localities—and hence those which contain most oxygen will under the same conditions give less tar and more water.

If a body such as coal or peat be placed in a close vessel and slowly raised to a red heat, a quantity of water existing ready formed in the substance will first distil over, decomposition will then commence, water will be formed from the elements of the turf, accompanied by acetic acid, wood spirit, carbonic acid, and carbonic oxide, and a small portion of marsh gas; the nitrogen will at the same time be in part converted into ammonia. When the greater part of the oxygen has been removed by the formation of the bodies just mentioned, a new series of bodies rich in carbon will be formed, those which are produced first being lighter and boiling at a lower temperature than those which pass over subsequently; and when, finally, the whole of the hydrogen is carried off in these combinations, the excess of carbon remains behind as charcoal or coke. Although we have here traced the successive stages of the distillation, there is in reality no very accurate separation possible between the moment when the water has ceased being formed and the commencement of the formation of the oily carbo-hydrogen. In general, long before the whole of the water products have passed over, vapours of oil make their appearance, and this the sooner the more rapidly the temperature is raised. If the temperature be very rapidly raised in the first instance, the vapours of water, and of the substances rich in oxygen and hydrogen, and a small amount of carbon, are decomposed by the surfaces of red hot coke which are continually forming carbonic acid, carbonic oxide and gaseous and liquid carbo-hydrogen being at the same time produced. Under such circumstances, independently of the nature of the substance, we would obtain, by a heat very rapidly raised, less charcoal, less water and products accompanying water, and more tar and gas. The two principal circumstances, therefore, influencing the relative proportions of the products are,—

1st. The relation between the amount of carbon and of oxygen and hydrogen in the substance.

2nd. The temperature at which the distillation is carried on, and the comparative rapidity with which the materials are brought to that temperature.

In our examination of turf, it was necessary to pay attention to both these points, and as on due consideration, the ordinary gas retort presented us with the simplest and best means of studying the question from both points of view, we procured a cast iron retort, 4½ feet long and 10 inches internal diameter, capable of being closed with a lid or mouth-piece exactly like an ordinary gas retort. It was set in brickwork, but its bottom was separated from the direct action of the fire by a fire-clay tile, the flame and hot air being made to pass through several apertures into the space immediately surrounding the retort, and thence into the flue. By this means the retort could be gradually brought to a bright red heat. About 6 inches of the retort projected beyond the brickwork, and from the top of this portion an U shaped tube made of ordinary 1½ inch gas-pipe passed into the condensers, the bend of the U being about 2½ to 3 feet above the retort. The arrangement for condensation consisted of three Wolff's bottles of tin-plate 20 inches high and 1 foot in diameter. The iron U shaped tube was connected by a coupling joint with a leaden tube which descended to the bottom of the first Wolff's bottle, and the third bottle was connected with a coil of leaden pipe about 18 feet in length arranged in a barrel of cold water like an ordinary worm of a still. Communicating with this worm, just where it issued from the barrel, was a small tar cistern to collect any liquid products which might be condensed in the worm, or carried into it from the Wolff's bottles by the rush of gas. The three Wolff's bottles were connected with each other in the ordinary way; the mouth-piece of the retort was luted on with the lime from the purifiers of the gas-works, where it is used for the same purpose.

In distilling with this apparatus, we employed two different temperatures with one variety of turf. In the first instance, we charged the retort, and then gradually heated it to a bright redness. The time necessary to bring it to this temperature was generally about 1½ hours. With the light surface peats it did not require this length of time, but with the dense varieties, it frequently exceeded 2 hours. At first very little gas was given off, but as parts of the retort attained a dull redness, carbonic acid mixed with a vapour of an excessively fœtid smell came off. As the heat increased, sulphurous acid, a little sulphuretted hydrogen, and abundance of carbonic oxide, with marsh gas, were formed. When the retort attained a full red heat, a strong stream of gas was given off, which was allowed to burn at the end of the worm, which it continued to do for each charge, from two to four hours, depending upon the density of the peat, and consequently upon the weight of the charge. It possessed considerable illuminating power; for about two-thirds of the time it was allowed to burn, being very little inferior to some ordinary varieties of coal gas. Towards the end, carbonic oxide and marsh gas of course predominated.

In employing the second temperature, we heated the retort to a bright redness, and then introduced the charge as in the gas-works. In this case, the gas was immediately given off, and, as was to be expected, of a better illuminating power than in the other case; the distillation also occupied a much shorter time.

We distilled altogether six varieties of turf, only one of which was distilled at the two temperatures, the other five having been treated in the way first described, that is, introduced into the retort when cold.

The quantity of turf employed for each experiment was one hundred weight, which was distilled in from 7 to 15 charges, according to its density. The charcoal of each charge was weighed separately, but the volatile products were not estimated until the entire hundredweight was distilled. The Wolff's bottles were then weighed, their contents emptied into a proper receiver, and the total weight of the solid and liquid products ascertained by the difference of weight between the vessels when charged and when empty. The tar and liquid were allowed to rest for two or three days in order to settle the liquid syphoned off, the tar collected on a cloth and weighed; the difference between the weight of the tar and the whole contents of the vessels giving the weight of water and soluble products, which were also estimated by direct weighing. The gas was calculated as loss.

DETERMINATION OF SUBSTANCES CONTAINED IN THE WATER.

Determination of Acetic Acid.—A weighed quantity of the water (about 3 lbs.) was treated with caustic soda and evaporated to dryness, and heated to about 350° Fahr., in order to semi-char adhering tar, &c., boiled with water, and filtered to separate pitchy matter, evaporated to a small bulk, introduced into a retort connected with a Liebig's condenser, treated with sulphuric acid, and distilled nearly to dryness. The distillat was treated with precipitated carbonate of baryta, and when completely saturated, heated for a few minutes nearly to boiling, in order to allow any sulphate of baryta present to precipitate, filtered, evaporated to dryness in a water-bath, and the acetate of barytes ($\mathrm{Ba\,O.\,\bar{A}+HO}$) weighed. A weighed quantity of this acetate was then dissolved in water, and the baryta precipitated by sulphuric acid, the sulphate of baryta collected on a filter, washed, dried, ignited, and weighed, and the quantity of acetic acid calculated from this result compared with that deduced from the dry acetate. Barytes was selected in preference to lime, as it gives a purer salt, and especially free from sulphuric acid.

Determination of Ammonia.—A weighed quantity (about 3 pounds) of the liquid was saturated with hydro-chloric acid, and evaporated to dryness, a water bath having been employed towards the end; the dried residue weighed, dissolved in water to separate tar, and accurately measured in a graduated cylinder. A small portion of the liquid was then taken, and the ammonia contained in it determined in the usual way by bichloride of platinum. The quantity of ammonia deduced from this result, deducted from the weight of the dry residue, gives the weight of soluble matter not driven off at 212° Fahr.

Wood-spirit or Naphtha.—The residue of the watery liquid, after the determination of the acetic acid and ammonia, and weighing generally from 30 to 35 lbs., was then accurately weighed, nearly saturated with sulphuric acid, introduced into a still, and one half drawn off. The residue was rejected, and the distillat again distilled over hydrate of lime, and this operation repeated until the distillat was reduced to between two and three pounds. The distillation was always conducted very slowly, so that the entire of the spirit passed over before the operation was ended. The distillat was next treated with excess of dried chloride of calcium in a retort, and set aside until the whole became solid, allowed to rest for some days and then distilled in a water-bath as long as anything passed over. The residue in the retort was then treated with about double its weight of water, and distilled in a water-bath as long as any alcohol came over. The liquid which passed over in the first distillation with chloride of calcium generally contained traces of spirit, and was again treated with chloride of calcium as before. The total product was then weighed, and the specific gravity determined.

DETERMINATION OF CONSTITUENTS OF THE TAR.

The quantitative determination of the constituents of the tar of peat, and indeed of any other substance, is exceedingly difficult, even of those bodies which are easily prepared in a state of purity. We were, consequently, obliged to devote a great deal of time in endeavouring to obtain a simple process, by which the bodies could be prepared in sufficient purity, and as little altered as possible. Indeed the difficulty of obtaining them unaltered is probably the greatest with which we had to contend. After a number of unsuccessful trials we found the following process to answer in the most perfect manner.

A small quantity of the fresh tar, immediately after having been weighed, was introduced into a flask, and weighed; it was then placed in warm water until the tar was completely fluid, the mouth of the flask being loosely closed with a cork, and then set aside to cool. When completely solidified, the water which had separated was removed as completely as possible, and the flask again weighed; this was the true weight of tar, and the difference gave the amount of water which remained mixed with the tar. From this result the true weight of the tar, and of the water obtained in the distillation, was easily calculated.

A weighed portion of the tar (generally about two to three pounds) was then introduced into a sufficiently capacious tin-plate Wolff's bottle, with two necks and having a cock at the bottom. A leaden pipe passing through one of the necks to the bottom of the vessel was attached at its upper end to a small boiler, by means of a steam-tight coupling joint. Through the other neck was passed a piece of similar leaden pipe, one end being connected with an ordinary worm well cooled, and the other end just entering the vessel. A jet of steam was then passed through the tar from the small boiler, the Wolff's bottle having been previously heated nearly to the temperature of boiling water so as to render the tar perfectly liquid. In a few moments the lighter oils came over freely, and if the temperature of the Wolff's bottle was raised to about 350° so as to prevent the condensation of the steam in it, the entire liquid and solid carbo-hydrogen, naphthalin, creosote, &c. came over in a very short space of time and with a very small expenditure of steam. After all oil had ceased to pass over, there remained in the Wolff's bottle a black pitchy mass, greasy to the feel, brittle, and exhibiting a resinous fracture and very fusible. When treated with caustic potash about one-half dissolved, leaving a brownish earthy-looking mass, which on drying resembled catechu. On being heated it softened, but could not be melted into a thoroughly fluid mass without decomposition. When the solution in potash was treated with hydrochloric acid, a black resin was precipitated. When melted, it formed a dark brownish-black pitchy mass. When placed in cold water it was exceedingly brittle and exhibited a perfectly resinous fracture; but when placed in a warm room, it gradually spread itself over the tube or other support upon which it was placed. In this semi-fluid condition it could be drawn into threads. It was soluble in ether, petroleum, turf-oil, and more sparingly in alcohol. Its solution in oil of turpentine resembles the ordinary Brunswick black varnish. In its general properties it bore remarkable resemblance to the substance known as *shoemaker's-wax*. The resin insoluble in potash was insoluble in alcohol, at least to any considerable extent, but dissolved in petroleum, turf-oil, &c., but it was on the whole less soluble than the resin soluble in potash. Both resins appear to combine readily with sulphuric acid, and to form conjugate compounds, which are however decomposed by a temperature even as low as that of boiling water. When kept for any length of time at this temperature, it gives off sulphurous acid gas, and then forms a thick varnish-like mass of an intensely black colour, which is completely precipitated on the addition of water. The resins thus obtained resemble one another perfectly, and present the usual appearances of similar compounds obtained with sulphuric acid. The object of our investigation being principally economical, and the time at our disposal very limited, we did not study these resins further, but from the considerations which we shall immediately offer, there can be no doubt that the matter is very well deserving of complete examination, which we hope in a short time to do. We endeavoured to obtain paraffine from them, but did not succeed, and a little closer examination showed us that they were true resins. On subjecting the original pitchy mass to distillation, there first passed over a small quantity of light oil containing traces of *benzin*—this was succeeded by a thick heavy oil the last portion solidified into a semi-crystalline mass; and on pushing the distillation gradually, until the bottom of the retort softened and sulphur-yellow fumes began to appear in the neck, there was obtained a quantity of an oily fluid, very nearly equal in quantity to that first obtained in the distillation by steam, but somewhat thicker than the latter, and in the retort remained a porous light charcoal.

There appears to be considerable variation in the relative proportions of these resins obtained in different distillations, but in general the quantity of the insoluble resin obtained far exceeds that of the soluble resin. The insoluble resin when distilled gives at first a little heavy oil, but towards the end of the operation paraffine distils over, requiring very little purification; in fact, nearly the whole quantity of that substance which was obtained appeared to be derived from the distillation of the resins, a fact which fully bears out the view which we have taken of the nature of the distillation. We are confident that on the large scale, a much larger quantity of paraffine may be obtained, by separating the oils directly from the tar, and then subjecting the residual pitch to distillation, than could be obtained by any other process.

The oils obtained in both processes were then mixed together, and subjected to distillation by steam, in the same manner as the tar. This operation proceeded far more rapidly than in the case of the tar, owing to the greater fluidity of the oils. The oil which first came over was of a light straw colour, very volatile, boiling below 212° Fahr., and consisting, in a great measure, of benzin. Gradually the colour of the product darkened; and when the distillation was complete it formed a dark olive-coloured thick oil, of an excessively fœtid odour, and acted upon the glass, forming a coating of metallic appearance of sulphuret of lead. When any oil ceased to come over the distillation was stopped, and the total weight of oily products ascertained in this second distillation; a considerable quantity of pitchy matter was always separated; indeed, these resinous bodies adhere with singular tenacity to the oils, and give them a slight tinge even when distilled with steam three or four times by simple distillation; *per se* it is impossible to purify them.

The oils were next poured into a large balloon, and treated with a quarter their weight of a mixture consisting of one part of caustic potash and three parts of caustic lime, to which five times their weight of water was added. The mixture was well shaken, and allowed to stand, occasionally shaking it, for twenty-four hours. At the end of this time the liquid had assumed a deep red colour, and the oil had formed with the potash and lime a sort of fatty semi-solid mass, at first of a dirty greenish hue, but subsequently becoming much darker. The liquor was poured off, and, when saturated with muriatic acid (or sulphuric acid) and distilled, a quantity of a heavy oil was obtained, containing the whole of the creosote, carbolic acid, &c.; but which we did not farther examine. The thick fatty mass was then treated with hydrochloric acid, and gently heated, so as to cause the oils to separate from the lime-residue, and collect in drops on the surface, and well agitated with the acid liquor to remove the organic bases, *anilin*, &c. The oily layer floating upon the acid liquor was then removed. Its colour was now of a very light brownish yellow, and it had, in a great measure, lost its disagreeable smell, owing to the removal of the sulphur by the potash and lime.

By subjecting the oil thus purified to another distillation it may be obtained almost colourless; in general we did not again employ steam, but proceeded at once to the separation of the different oils and of the paraffine. For this purpose the oils were introduced into a retort, and distilled at first in a bath of salt and water, to separate, as far as possible, the benzin by distillation. When nothing distilled at this temperature the retort was slowly heated over charcoal, until 15 to 20 per cent. had passed over, when the receiver was changed, and the heat raised until a portion equal to about 40 to 45 per cent. of the original oil had passed over, when the receiver was again changed, and the distillation continued, with a slight increase of temperature, until another portion, equal to about from 15 to 20 per cent. of the original oil had passed over. The residue in the retort was then poured into a basin, and allowed to cool slowly; when cold it formed a solid mass, having a somewhat crystalline structure.

It was then placed in a double bag of linen cloth and gently pressed, keeping the temperature as low as possible; by immersing the bag in cold water, a quantity of thick brownish oil, almost destitute of smell, was squeezed out. When the greater part of the oil was squeezed out with a gentle pressure the mass was cooled as much as possible, and the pressure increased until all traces of oil were squeezed out. When the oil, thus separated, was subjected to great cold, an additional quantity of crystalline matter was obtained. With the small masses upon which we were obliged to operate, the separation of the oil in this way was very difficult. The solid mass which remained in the cloth, together with the portion which crystallized from the oil, was then fused with water in a basin, allowed to cool, the water poured off, and the mass heated to near 212° for one or two hours, with about its own weight of oil of vitriol, which removed all adhering resins and oil; on allowing the mass to cool, and washing it with water, and fusing it once or twice in water, it formed a greyish-white mass, very brittle and crystalline, fusing at from 110° to 111°. It was then dissolved in absolute alcohol at a boiling temperature from which it separated on cooling in beautiful pearly scales of considerable size, which were collected on a filter, fused, allowed to cool, and weighed. The products separated in this way were as follows:—

1. A volatile oil boiling under 212° Fahr., and forming about 5 per cent., and containing a large quantity of benzin.
2. A volatile oil, having a boiling point from 266° to 320° Fahr., forming from 15 to 20 per cent.
3. An oil boiling from 320° to 550° Fahr., and forming about 35 to 40 per cent.

(These three oils correspond with the volatile oil of Reece.)

4. An oil boiling above 550°, part of which is obtained by distillation, and another part by expression, from the paraffine, and forming about 30 to 35 per cent of the crude oil before separation of creosote.

(Corresponding to the fixed oil of Reece.)

5. A solid crystalline carbo-hydrogen, considered as paraffine.

Before adopting this process by steam, we usually subjected the tar to distillation, which we carried on with a temperature gradually raised until the bottom of the retort melted, and nothing remained in it but a porous charcoal, then treating the crude oily mass thus obtained as above described with a mixture of lime and potash, but we never obtained very constant results by this means, nor were the products as pure. By the steam we were enabled to get a product which required little or no bleaching, was very free from disagreeable smell, whilst with the other it was almost impossible to remove the last traces of either the colour or odour.

When we wished to obtain the oils perfectly free from colour, and sufficiently pure to remain so when exposed to the action of light, they were treated directly, as they were obtained in the first distillation with steam, with bichromate of potash and a very little sulphuric acid, allowed to stand for a day or two, occasionally agitating the mixture, then syphoning them off, washing them with potash, and then distilling them. If allowed to stand for two months in contact with bichromate of potash alone the same result will be obtained, without the disadvantage of employing oil of vitriol, which has in every case an injurious action upon oils intended to be used as solvents. There is also less loss of oils where the bichromate alone is employed, as the oil of vitriol sets free a considerable quantity of chromic acid which acts with great energy upon the oil.

We have not as yet been able to examine whether there is any difference between the oils obtained by distillation with steam from the crude tar and those produced by its dry distillation. It is, however, probable that there is some difference at least in physical character, for it is not to be supposed, that a complex mixture like tar could be kept for a considerable time at the temperature necessary for its distillation without undergoing change. We have also uniformly obtained a larger product by the steam process than by the dry distillation of the tar, especially of paraffine. We are of opinion that in the crude oil obtained by the distillation of the tar, two perfectly distinct series of bodies exist: the first consisting of the lighter oils formed in the distillation of the peat, and the second the products of the dry distillation of the resinous bodies, formed in the same operation, and which we succeeded in separating from the tar by means of steam. It is probable that the whole, or at least the greater part of the "fixed oil," paraffine, naphthaline, &c., are the products of this second distillation. It is no objection to this view that naphthaline exists ready formed in coal tar, because that substance is really not the product of the simple distillation of coal, but a mixture of tar of the first distillation, with the products of distillation of part of that tar itself. From the high temperature employed, and the absence of any comparatively large quantity of water in the coal from which gas is manufactured, the vapours of the tar are in great part subjected to complete distillation, and these products mixed with a portion of the undecomposed tar vapours form what we denominate gas tar. The appearance of the gas coke, as well as the production of artificial graphite in the gas retorts, which is the charcoal formed from the destructive distillation of the tar, bear out this view of the matter completely. In one of our experiments, where we commenced the distillation of the peat at a full red heat, we obtained some results supporting this view in a remarkable manner. A quantity of the tar condensed in the upright tube which carried off the products from the, retort and was there acted upon by the steam formed from the turf. A hard pitchy mass was formed in the tube resembling in everything the residue of the action of steam upon the tar; but as the distillation of the volatile products from the retort through the tube ceased, the temperature, which was kept comparatively low by the vapours passing through it, rose, and the pitchy mass, at the end nearest the retort, was subjected to complete distillation. Very nearly one-half of the tar was then subjected to a second distillation, and when a portion of it, at a point where the heat had not been sufficiently high to drive off all volatile matters, was treated with ether, crystals of paraffine were observed, whilst none could be obtained from the upper end of the pitchy mass which had not been so distilled a second time.

The extraordinary similarity between the products obtained from turf and those obtained from the oil which is formed in the manufacture of rosin gas is certainly very curious, and is not without value in reference to the view which we have put forward above, as to the nature of the first distillation of vegetable substances; and although we wish to avoid theoretical considerations as much as possible in the present report, we cannot refrain from making a few additional remarks upon the subject, as it is of great importance that the true nature of the process which we have adopted for the separation of the oils from the tar should be thoroughly understood.

The oil above mentioned is obtained in Paris in considerable quantities, and has been applied technically. Its examination was made by Pelletier and Walter.* It is of a dark brown colour; it commenced to boil at 266° Fahr., and continued to do so until it reached 320°, when it ceased, and the temperature then rapidly rose to 536°, when the distillation again commenced, and so continued until it gradually reached 662°. Three different products are thus obtained which are employed in the arts. The first, or that which passes over between 266° and 320°, is called in the manufactory *vive essence*, the last portion containing a little naphthaline. What passes at 336° is denominated *huile fixé,* and that which passes above 662° is called *matière solide.* It is probable that there is a greater number of oils in what we might call the *vive essence* of the turf oil, but the *huile fixé* resembles in most particulars the *fixed oil* of peat. It is a thick oleaginous fluid of a brownish colour, which appears blue on the edges, apalescent, and sometimes muddy. It is cleared by treatment with a ley of potash of 41° of Beaume, in which condition it is used to paint the exteriors of buildings, &c. The *matière solide* yields a white crystalline substance which crystallizes in mother-of-pearl-like shining plates, and which melts at 152° Fahr. This body is not paraffine. Pelletier and Walter call it *metanaphthaline,* and Dumas retisterene. It has many of the properties of paraffine, but, unlike it, it is converted into an ochre-yellow resinous body by nitric acid. We have some reasons to consider the similar substance obtained from turf not to be the body usually described as paraffine, but as its identity or non-identity with that substance is of little importance in an economic point of view, we shall say nothing further of the matter here.

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* Berz. Jahrb. xix. 608.

If the view which we have put forward regarding the nature of the dry distillation of vegetable matter be correct, we shall have at once a key to the formation of the bodies just mentioned derived from rosin, as well as to the formation of turpentine, of petroleum, and many other phenomena, both chemical and geological.

Before concluding this part of the subject, we may remark that we could not succeed in obtaining the oils from the tar in the manner described by Mr. Reece. There can be no doubt, from what we have already remarked with reference to the action of sulphuric acid upon the resinous bodies in the tar, and especially upon the facility with which they are decomposed at a temperature below that of boiling water, and converted into hard resins, that oil of vitriol is capable of removing them completely; but certainly not the quantity employed by Mr. Reece, which, if his tar resembles that obtained by us, would form only about 5 per cent. of it. Now, although from the nature of the products of distillation of these resins, their atomic weight must be high, still we do not know of any resinous bodies which would combine in that proportion with sulphuric acid. We tried the experiment on several occasions, but without success. Thus, with 1 lb. of tar we employed 1 oz. of oil of vitriol, then 2 oz., and so on, until we had employed a quantity equal to about 20 per cent. of the tar, before we obtained anything like a successful result. The only way in which we can account for this great difference in our results, is, that the quantity of resin in the tar obtained by Mr. Reece is much less than in our tars, owing to the tar having been subjected to second distillation from the high heat employed. But even supposing that such was the case, we believe that better results and larger proportions of products could be obtained by the use of high-pressure steam than by sulphuric acid, especially as the action of the latter upon the oils very much deteriorates their *solvent* powers—pyrogenous oils dissolving caoutchouc and gutta percha, and much more readily before treatment with sulphuric acid than after. With steam of two or three atmospheres' pressure, the distillation would be quite perfect; for we may remark that paraffine will not come over with the vapour of water of a temperature of 212°; and hence, as we have mentioned in the description of our process, we heated the vessel containing the oils and tar to a considerable degree, but the same effect would be brought about, in the first instance, much better by the use of high-pressure steam. Where the quantity of oil is large, and that of the paraffine small, the temperature at which the latter passes over with the vapour of water is lower; indeed, in such case, traces go over with ordinary steam; but where the paraffine is merely mixed with a small quantity of oil, it may be exposed for hours to the action of steam of ordinary pressure without any sensible loss, being, in fact, purified by the operation, the entire of the liquid oils being carried off.

We shall now give a short *résumé* of the results which we have obtained, and, before doing so, shall give a short statement of the absolute quantities obtained in each distillation. For the per-centage results deduced from these we refer to the tables annexed. We have also thrown the descriptions and notices of the localities into the form of a table, as we believe that the best way of rendering a series of experiments of practical use, is to put them in as small a space as possible, and with as few words as is consistent with clearness, before the eye; and this, of course, is best effected by tables. With reference to the descriptions which we have given of the localities, we may state that the numbers, &c. are derived from the valuable Report of the Commissioners appointed to examine into the Nature and Extent of the Bogs of Ireland; and principally from the reports of Richard Griffiths, Esq. Where possible we have given the number of acres and the depth of the bog, and the fall; the first, in order to show the extent of bog represented by the specimen, and the second, the probable capability of drainage—a matter of considerable importance—1st, as influencing the cost of the preparation of the turf; and 2ndly, the value of the reclaimed land.

DETAIL OF THE RESULTS OBTAINED BY THE DISTILLATION OF SIX VARIETIES OF PEAT.

The first peat distilled consisted of a mixture, in about equal proportions, of the light and dense peats from Mount Lucas Bog, near Phillipstown, being, in fact, the peat as it is sold for fuel in Dublin. The quantity distilled was larger than that of any of the other varieties—1 cwt. as already mentioned, being the quantity employed in all the other cases. Being the first specimen examined, the process by which the different constituents of the tar and water were estimated was somewhat different from that described above, and by which all the others were determined. We may also remark, that, probably on account of the imperfections of the process, and our not being as well acquainted with the bodies as subsequently, the percentage of oils and of paraffine is too low, certainly the latter.

The ammonia in this instance was determined in two parts. The part existing as carbonate having been separated from that combined in the liquid with acetic acid, by simple distillation. This is the essential difference between the processes; the other points of difference having reference more to the rapidity and convenience of analysis, and the facility of calculating the results, we do not think it necessary to give any further details, and shall at once state the absolute numbers obtained.

Phillipstown.

180½lbs. = 1,386,240 grains avoirdupois of turf, gave—

Charcoal 67½ lbs. = 518,400 grains.

Crude Tar 3 lbs. 6 oz. 4 drms. = 26,040 grains { Tar . 23·043 grains.
Water. 2997·4 ,,

This crude tar yielded —

Water	2,997 grains.	
Paraffine	324·24 ,,	
Oils	15,986 ,,	
Charcoal	4,246 ,,	From distillation of resins.
Gas	2,486·76 ,,	
Total	26,040	

Total—Water = 42lbs. 7oz. = with water of tar, 328,917grains, yielded—

Chloride of Ammonium existing as carbonate	11,717 grains	Total Ammonia 13,165·9 grains.
Chloride existing as Acetate and in other combinations	1,448·9 ,,	
Acetic Acid	1,060·4 ,,	
Wood Spirit	1,283·5 ,,	

The result of each charge in charcoal was as follows—

Charge.	Turf.	Charcoal.
1	12½ lbs.	5 lbs.
2	14 ,,	5 ,,
3	12 ,,	4½ ,,
4	12 ,,	5 ,,
5	12 ,,	5 ,,
6	12 ,,	5 ,,
7	16 ,,	6 ,,
8	12 ,,	4½ ,,
9	12 ,,	5 ,,
10	15 ,,	4 ,,
11	12 ,,	4½ ,,
12	12 ,,	4 ,,
13	10 ,,	3 ,,
14	7 ,,	3 ,,
15	9 ,,	4 ,,
Total	180½ lbs.	67½ lbs.

Dense Peat. Wood of Allen.

1 cwt. = 860,160 grains of peat yielded—

Charcoal 36 lbs. 8½ oz.

Crude Tar 28,250 grains { Tar . . 23,805 grains.
Water . 4,445 ,,

Crude tar yielded—

Water	4,445 grains.	
Paraffine	646 ,,	
Oils	9,780 ,,	
Charcoal	4,365 ,,	From distillation of resins.
Gas	9,014 ,,	
Total	28,250	

Total water = 327,745 grains, which yielded—

Chloride of Ammonium . . .	10,635 grains.
Acetic Acid	2,463 "
Wood Spirit	1,625 "

The result of each charge in charcoal was as follows—

Charge.	Turf.	Charcoal.
1 . .	14 lbs. . .	4 lbs. 9¾ oz.
2 . .	14 " . .	4 " 6¼ "
3 . .	14 " . .	4 " 5¾ "
4 . .	14 " . .	4 " 10 "
5 . .	14 " . .	4 " 8 "
6 . .	14 " . .	4 " 15 "
7 . .	14 " . .	4 " 9¼ "
8 . .	14 " . .	4 " 8½ "
Total .	112 lbs. . .	36 lbs. 8½ oz.

Light surface Peat. Wood of Allen.

1 cwt. = 860,160 grains of peat yielded—

Charcoal 43 lbs. 13¼ oz. = 336,600 grains.

Crude Tar 4 lbs. 11 oz. 14 grains = 36,014 grains { Water . 5,240 grains.
{ Tar . 30,774 "

Crude tar yielded—

Water	5,240 grains.	
Paraffine	1,546 "	
Oils	12,746 "	
Charcoal	6,832	From distillation of resins.
Gas	9,650	
Total . . .	36,014	

Total water — 277,606 grains, which yielded—

Chloride of Ammonium . . .	5,065 grains.
Acetic Acid	1,779·5 "
Wood Spirit	1,476·5 "

The results of each charge in charcoal was as follows—

Charge.	Turf.	Charcoal.
1 . .	8 lbs. 0 oz. . .	3 lbs. 0 oz.
2 . .	9 " 8 " . .	3 " 15½ ,
3 . .	10 " 0 " . .	3 " 11 "
4 . .	8 " 0 " . .	3 " 4¼ "
5 . .	8 " 0 " . .	3 " 2 "
6 . .	8 " 0 " . .	3 " 2 "
7 . .	10 " 0 " . .	3 " 14 "
8 . .	10 " 0 " . .	3 " 14 "
9 . .	10 " 0 " . .	3 " 14 "
10 . .	8 " 0 " . .	3 " 3 "
11 . .	8 " 0 " . .	3 " 3 "
12 . .	8 " 0 " . .	3 " 3 "
13 . .	6 " 8 " . .	2 " 7½ "
Total .	112 lbs. 0 oz. . .	43 lbs. 13¼ oz.

Ticknevin Turf.

1 cwt. = 860,160 grains of turf yielded—

Charcoal 267,600 grains.
Crude Tar 31,860 grains {Tar . 25,083 grains. Water 6,777 „

Crude tar yielded—

Water . . .	6,777 grains.	
Paraffine . . .	1,468 „	
Oils	16,165 „	
Charcoal . . .	6,888 „	From distillation of resins; temperature very low, hence the quantity of gas was small.
Gas	0,502 „	
Total . .	31,860 „	

Total water — 289,257 grains, which yielded—

Chloride of Ammonium . .	2278·4 grains.
Acetic Acid	1688 „
Wood Spirit	1266 „

The result of each charge in charcoal was as follows—

Charge.	Turf.	Charcoal.
1	8 lbs.	2½ lbs.
2	8 „	2½ „
3	8 „	2½ „
4	8 „	2 „ 7½ ozs.
5	8 „	2½ „
6	8 „	2½ „
7	8 „	2½ „
8	8 „	2½ „
9	8 „	2½ „
10	8 „	2½ „
11	8 „	2 „ 7½ ozs.
12	8 „	2 „ 7½ „
13	8 „	2 „ 7½ „
14	8 „	2 „ 7½ „
	112 lbs.	34 lbs. 13½ ozs.

Ticknevin Turf distilled with Retort first raised to a bright red heat.

1 cwt. = 860,160 grains of turf yielded—

Charcoal 28¼ lbs. = 201,600 grains.
Tar . . . 20,170 „

Tar yielded—

Water	None.	
Paraffine	1,691 grains.	
Oils	11,260 „	
Charcoal	4,776 „	From distillation of resins.
Gas	2,443 „	
Total . . .	20,170 grains.	

N.B.—The tar, having come over at a high temperature, united at once into a solid mass, and hence it contained no water mingled with it.

Total water — 276,000 grains, which yielded—

Chloride of Ammonium	5277·9 grains.
Acetic Acid	1791 „
Wood Spirit	1386·5 „

The result of each charge in charcoal was as follows—

Charge.	Turf.	Charcoal.
1	7½ lbs.	2 lbs.
2	7 „	1¾ „
3	7½ „	1½ „
4	7½ „	1¾ „
5	7½ „	1½ „
6	7½ „	1¾ „
7	7½ „	2 „
8	7 „	2 „
9	7½ „	1¾ „
10	7½ „	1½ „
11	8 „	1½ „
12	7½ „	1¾ „
13	7 „	2 „
14	8 „	2 „
15	7½ „	2½ „
	112 lbs.	27¼ lbs.

The amount of the three charges of charcoal having been considered too high, they were again distilled.

Before distillation	6½ lbs.
After ditto	5½ „
Loss	1 lb.,
which substracted from the total	27½ lbs.
gives as true weight of charcoal	26¼ lbs.

Light surface Peat from Shannon.

1 cwt. = 860,160 grains yielded—

Charcoal 25 lbs. 10 oz. = 187,200 grains.

Crude Tar 4 lbs. 15 oz. 80 grains = 38,000 grains { Tar . 28,504 grains. Water . 9,496 „

The crude tar yielded—

Water	9,496 grains.	
Paraffine	1,561 „	
Oils	12,986 „	
Charcoal	10,785 „	From distillation of resins.
Gas	3,172 „	
Total	38,000	

Total water — 337,456 grains, which yielded—

Chloride of Ammonium	10,947 grains.
Acetic Acid	1,762 „
Wood Spirit	1,134·6 „

The result of each charge in charcoal was as follows—

Charge.	Turf.	Charcoal.	
1	9 lbs.	2 lbs.	
2	9 „	2 „	8 ozs.
3	9 „	2 „	
4	9 „	2 „	
5	9 „	2 „	
6	9 „	2 „	
7	9 „	2 „	
8	9 „	2 „	
9	9 „	2 „	
10	9 „	2 „	
11	9 „	2 „	4 ozs.
12	9 „	2 „	
13	4 „	0 „	14 „
	112 lbs.	25 lbs.	10 ozs.

Very dense Peat from the Shannon.

1 cwt. = 860,160 grains of turf yielded—

Charcoal . .	163,200 grains.
Tar . . .	12,577 „

The tar was obtained in this instance free from water, owing to the high temperature at which the distillation occurred, caused by the great density of the turf, which did not commence to distil until the retort had attained a full red heat.

The tar yielded—

Paraffine . .	967 grains.
Oils . .	7,856 „
Charcoal . .	2,046 „
Gas . .	1,708 „
	12,577 „

Total water = 187,686 grains which yielded—

Chloride of Ammonium . .	4,908 grains.
Acetic Acid	1,391·6 „
Wood Spirit	1,028·8 „

The result of each charge in charcoal was as follows—

Charge.	Turf.	Charcoal.
1 .	15½ lbs.	. 4 lbs.
2 .	17 „	. 4 „
3 .	18½ „	. 4 „
4 .	19½ „	. 4 „
5 .	19 „	. 3¾ „
6 .	19 „	. 3¾ „
7 .	4 „	. 0¾ „
	112½ „	24¼ „

Owing to the great density of this peat, several bricks of peat from the different charges were not sufficiently charred; these were therefore selected and burned in two charges with the following results:—

Charge.	Charred Peat.	Perfect Charcoal.
1 . . .	8½ lbs.	. . 6½ lbs.
2 . . .	9 „	. . 8 „
Total . .	17½ „	14½ „

giving a loss of 3 lbs., which subtracted from 24¼ leaves 21¼ lbs. as the true weight of charcoal.

PART III.—DISTILLATION OF PEAT BY MEANS OF A BLAST OF AIR.

The distillation of peat in a closed cylinder having furnished sufficient data enables us to judge of the nature and proportions of the products of distillation of peat, we did not think it necessary to operate upon more than from one-fourth to half a cwt. of turf, in the distillations conducted in a blast of air, as our principal object was to obtain points of comparison; for the same reason we did not separate the volatile and fixed oils. The pyroxylic spirit was always weighed, as in other cases, at a specific gravity of 830°, being that of the usual commercial article.

The apparatus employed consisted of the cylinder, already described in speaking of the distillation of peat in closed vessels. It was placed in an upright position, the blast of air being introduced by a piece of gas-pipe attached to the nozzle of a forge bellows of considerable power, and screwed into the side of the cylinder, about one inch above the internal surface of the closed end. The open end was closed by a lid, and luting as in the other distillations; and the same arrangement was made for condensation, with the addition of making the gas bubble through a considerable quantity of cold water before it was passed into the chimney.

In our first experiments we found it almost impossible to effect a complete condensation, and even when we did, the pressure which we were obliged to use, in sending the blast of air through the apparatus, was so great, that we are confident that the expense will be enormous, if a proportionable force be found necessary on the large scale. The difficulty of effecting a condensation was not, however, our only one, as we found it almost impossible to regulate the amount of air which was necessary to effect the combustion of the charge. Indeed, this is one of the greatest difficulties which will be encountered in carrying out the process on a large scale. If too little air be blown through, the combustion will go on slowly and imperfectly, and the quantity of peat which can be consumed in a given time will be exceedingly small; if too much, scarcely any products will be obtained. Thus, for instance, in our first attempt we employed a charge of nine pounds of turf from Phillipstown (No. 2 in Table I), which occupied eight hours for its complete combustion, and yielded but two pounds three ounces of water, and only 120 grains of tar. The following table contains the results of several other unsuccessful experiments:—

Variety of Peat employed.	Number of charges and amount of each charge.		Total weight of Turf employed.	Water.		Tar.
	st.	lbs.	lbs.	lbs.	ozs.	grains.
No. 2. Phillipstown.	1	9	26½	6	14	410
	2	8½				
	3	9				
No. 7. Light Wood of Allen.	1	9	28	7	14	526
	2	10½				
	3	8½				
No. 22. Shannon, No. 2.	1	7½	31¾	5	8	110
	2	8				
	3	8¼				
	4	8				

The tar obtained in these experiments was quite solid, and consisted almost entirely of the resin already mentioned in speaking of the distillation of peat, the whole of the oils having been apparently carried off by the blast. In every case of imperfect combustion the aqueous liquor was strongly acid at the end of the operation, whilst in the operation with closed cylinders, and also with the subsequent distillations in a blast of air, in which the combustion was regular and complete, the re-action, although acid in the commencement of the operation, gradually became alkaline as the temperature and the rapidity of the distillation increased.

Although the blast of air blown through the apparatus was very large comparatively to the charge of turf employed, the temperature never rose very high, owing to the great pressure, and in no case did the cylinder become red-hot, it would have been impossible therefore that the residual ash could have slagged; indeed, a glance at the table representing the composition of peat-ashes at once shows that the heat necessary to fuse such a mixture must be exceedingly high. Cases may however occur of mountain turfs, especially those mixed with the *débris* of decomposing granite or basalt, yielding more fusible ashes; still, even in such cases, the temperature should be far higher to effect their fusion than any which we ever succeeded in producing. In endeavouring to effect complete condensation, which was finally effected by a slow and regular blast, the handle being worked at the rate of from 4 to 5 strokes per minute, the evolved gases being made to pass through a column of two feet of water before passing into the chimney, we found the time necessary to burn one charge completely to vary from 6 to 9 hours; the amount of products being in almost direct proportion with the duration of the operation. So slow was the combustion under these circumstances, that it was sometimes impossible to say whether it had not ceased altogether. The tar obtained in these experiments was consequently very rich in ulmin-like resinous bodies similar to those before noticed, and consequently not so viscous as that obtained by close distillation. There would consequently be great difficulty in preventing the condensation apparatus from getting choked in carrying out the distillation on the large scale; at least there would be more danger than in gas-works, where the tar obtained from the coal is liquid.

Notwithstanding the difficulties of regulating the blast and effecting the complete condensation of the products, the following results, obtained with considerable trouble, but in which the difficulties just mentioned were completely obviated, coincide in a very remarkable manner with those obtained by distillation in the ordinary way (see Tables VII. and VIII.), and thus fully bear out the view which we have taken of the nature of the process.

The separation and determination of the products were made in the same manner as the similar ones from the distillation in closed vessels. The products appeared to be, however, much more impure, the methylic alcohol and acetic acid especially. We shall now give the details of the successful distillations.

No. 7.—*Light Surface Peat.—Wood of Allen.*

1st charge	10 lbs.
2nd „	10 „
3rd „	10 „
Total	30 lbs. = 234,246 grains avordupoise.

Which yielded when perfectly burned:—

Water 9lbs. 8 ozs. 6 grs. = with 1240 grains separated from tar to	74,206
Tar	5,880
Ash	5,840
Gas and non-condensed vapours estimated as loss	148,320
Total	234,246

The tar yielded:—

Paraffine	396 grains	
Oils	2860 „	
Charcoal	987 „	From distillation of the tar.
Gas	1637 „	
Total	5880 grains.	

The water yielded :—

Chloride of Ammonium	2370·7 grains.
Acetic Acid	420·17 „
Pyroxylic Spirit	371 „

No. 9.—*Dense Peat.—Wood of Allen.*

1st charge	11 lbs.	8 oz.
2nd „	13 „	0 „
3rd „	11 „	4 „
Total	35 lbs.	12 oz. = 274,560 grains avoirdupoise.

Which yielded when perfectly burned ;—

Water 10 lbs. 13 oz. 130 grains = with 1021 grains of water from tar	84,191 grains.
Tar	6,576 „
Ash	19,840 „
Gas and non-condensed vapours	163,953 „
Total	274,560 grains.

The tar yielded :—

Paraffine	236 grains.	
Oils	2600 „	
Charcoal	1220 „	From distillation of tar.
Gas	2520 „	
Total	6576 grains.	

The water yielded :—

Chloride of Ammonium	2237·4 grains.
Acetic Acid	737 „
Pyroxylic Spirit	431 „

No. 24.—*Shannon* (No. 4).

1st charge	18½ lbs.
2nd „	17 „
3rd „	18 „
Total	53½ lbs. = 407040 grains.

Which yielded when perfectly burned :—

Water 120,812 grains, which with 560 grains from the tar, =	121,372 grains
Tar	9,241
Ash	11,690
Gas and non-condensed vapours	264,727
Total	407,040

The tar yielded :—

Paraffine	487 grains.	
Oils	4120 „	
Charcoal	1896 „	From distillation of the tar.
Gas	2738 „	
Total	9241 grains.	

The water yielded :—

Chloride of Ammonium	1868·8 grains.
Acetic Acid	711 „
Pyroxylic Spirit	432 „

PART IV.—EXAMINATION OF THE GASES EVOLVED DURING THE DISTILLATION OF PEAT IN A BLAST OF AIR.

According to Mr. Reece, the gases evolved during the distillation of peat in a blast of air are combustible; hitherto we have not succeeded in obtaining any combustible gas under such circumstances. Our experiments upon this point were conducted in a great variety of ways. Not having succeeded in obtaining any combustible gas in the experiments just detailed, we tried a slower blast, and a stronger and more rapid blast, but without effect. In the experiments where we succeeded in effecting complete condensation, every circumstance was favourable to the production of such a gas, if the views of Mr. Reece be correct, nevertheless, the gas was incapable of igniting at every period of the distillation. According to him, the whole of the coke is converted in carbonic oxide; now as this gas is only formed at a high temperature, or at least is only formed as the largest product at a high temperature, it could not be expected that it would be formed at the temperature necessary to distil the peat with due attention to the formation of tar and ammonia. On the other hand, it ought to be formed where the combustion is very rapid, but where the tar and water are nearly all lost; but even under such circumstances we did not obtain any gas capable of igniting.

The gases evolved from such a distillatory blast furnace as that described by Mr. Reece, would according to him consist of carbonic oxide, nitrogen, and carbo-hydrogen. The relative proportions of these gases must of course depend upon the force of the blast and the rapidity of the combustion; but if we suppose that a complete distillation of the turf would have taken place before the resulting coke could come in contact with the oxygen of the blast, and that the whole of the coke was then converted into carbonic oxide, we would have the most perfect theoretical conditions of the case, and under such circumstances at least, the gas ought to possess all the qualities demanded by Mr. Reece. Now if we assume that 100 tons of peat yields 35 tons of coke and 250 tons of combustible gases, there would be formed a mixture of gases containing 81·6 tons of carbonic oxide, 186·80 tons of nitrogen, and 20 tons of combustible gases; that is, about 2 volumes of nitrogen to 1 of carbonic oxide, and about $\frac{1}{4}$ of carbo-hydrogen, or about 2 volumes of non-combustible gas to $1\frac{1}{4}$ of combustible gas; but such a mixture is slightly explosive when mixed with a little air, although under certain circumstances it will burn, provided the orifices are large and *the pressure very small.* Even a mixture of 3 volumes of nitrogen and 1 of carbonic oxide, or one of a mixture of 1 volume of carburetted hydrogen and 1 of carbonic oxide will burn when large surfaces are exposed to the air, and no pressure exerted, for even carbonic oxide in a pure state burns with difficulty under a slight pressure, and owing to the small amount of heat evolved in its combustion as the experiments of Favre and Silbermann clearly show, scarcely at all from common Argand gas jets, unless first heated nearly red-hot. Thus, even with the most favourable theoretical conditions, the difficulties of employing such a gaseous mixture as a sole source of heat would be very great, but in practice they would be still greater. The carbo-hydrogen given off from turf consists in great part of marsh gas, and almost entirely of that gas when the distillation takes place at a low temperature; and the whole of the carbon is never converted into carbonic oxide, a large quantity of carbonic acid being also always produced; and even at low temperatures nothing but carbonic acid is produced; it is therefore easily seen why we could not obtain a combustible gas. It would also appear that part of the carbo-hydrogen is decomposed by the action of the blast, especially if strong; for if the blast of air be stopped for a moment when the distillation is at its maximum, the gases evolved by heated turf burn, but the moment the slightest current of air is passed through the gases cease to be combustible. Even the current produced by the fall of water from a Brunner's Aspirator is sufficient to stop the combustibility of the gases produced. From these considerations we may safely conclude that, in practice, if it is found necessary to produce carbonic oxide, the temperature must be so much raised that it will be impossible to obtain tar; and that if the process is carried on sufficiently slowly to obtain tar, no carbonic oxide will be obtained.

No. VI.

TABLES REFERRED TO IN GENERAL REPORT.

TABLE I.—Representing the Specific Gravities, and containing Descriptions of the Specimens, and the names of the Localities from whence obtained.

Number of Specimen.	Specific Gravity.	Description.	Locality from whence obtained, and General Observations.
1	0·247 0·307 to 0·337	Excessively light spongy surface peat of a reddish brown colour, composed almost entirely of Sphagnum species still distinguishable	From the immediate neighbourhood of the town of Monastereven.
2	0·405	Light surface peat, of a pale reddish brown colour, containing small roots of Erica, and leaves of grasses and carex . .	Both specimens from Mount Lucas Bog, lying one mile south of the town of Phillipstown, in the King's County. According to Griffith's survey, made in 1810, this bog covers 6582 acres. Its highest point above high water of Dublin Bay, 294 feet, and lowest point, 214 feet, and its average thickness 18 feet. The entire district about this town is covered with bogs, averaging from 1000 to 8000 acres in extent, and having an average depth of from 18 to 20 feet.
3	0·669	Rather dense peat from the same bog as the last-mentioned specimen. Of a dark reddish brown colour. Structure of moss still distinguishable, but species difficult to be determined	
4	0·235 0·507 to 0·598	Light reddish brown fibrous moss peats. The Sphagnum almost unaltered, as well as the leaves of carex and other plants, and the roots of species of Erica .	From Ticknevin, in the county of Kildare, close to the twentieth lock on the Shannon Harbour Branch of the Grand Canal, which here forms a kind of boundary between the Timahoe and Lullymore Bogs. The specimen was

TABLE I.—*continued.*

Number of Specimen.	Specific Gravity.	Description.	Locality from whence obtained, and General Observations.
			obtained from the north-eastern extremity of the Lullymore Bog, which is, in reality, but the western continuation of the Timahoe Bog, the only natural boundary being a ridge of gravel. It contains 16,247 acres. Its highest point is 256 feet above high-water in Dublin Bay, and its lowest 214 feet. Its average depth is 20 feet, but it reaches in some places 40 feet.
5	0·310 0·347 to 0·396	Upper layer of fibrous or red bog, composed entirely of Sphagnum, Hypnum, and other mosses, the species of which can be readily distinguished . . .	From Derrymullen, the station of the Irish Amelioration Society. This bog is a small detached part of the Lullymore Bog, lying between its south-eastern extremity and that part of the Great Timahoe Bog called the Wood of Allen, from which Nos. 6, 7, and 8 were obtained.
6	0·596 0·657 to 0·701	Dense peat, of a blackish brown colour. Vegetable structure nearly obliterated. Roots of Erica, leaves of grasses and carex, and twigs of hazel, and apparently of birch, sometimes found . . .	
7	0·335	Light surface peat, pale yellowish brown, moss very open, grained, and fibrous. Principally composed of Sphagnum, Hypnum, &c. The species of which may be readily distinguished .	Nos. 7, 8, and 9 were obtained from the Wood of Allen, which forms part of the Great Timahoe Bog, lying to the north-east of the Grand Canal to Shannon Harbour. The specimens were obtained from the part of the bog close to the banks of the canal, about two miles from Robertstown, in the County Kildare. The Derrymullen Bog, last-mentioned, may be considered as part of this bog; the greater part of it, however, lies at the opposite side of the canal, and between the latter and the branch to Athy. The distance between where the specimens 6, 7, and 8 were obtained, and the works of the Irish Amelioration Society. not being quite two miles. Timahoe Bog, according to Griffith's survey in 1810, contains 12,878 acres. Highest point of the bog above high-water. 289 feet; lowest point, 232; average depth, 25 feet.
8	0·371 to 0·581	Middle layer of same bog. Colour, deep reddish brown. Mass tolerably compact, but still fibrous. Structure of the moss very indistinct. A very few roots of Erica and small twigs of birch and alder, and scales of fir . . .	
9	0·639 to 0·672	Lower layer of the same bog. Mass compact and dense. Colour, deep blackish brown. Fracture earthy, appearing almost conchoidal, and exhibiting a resinous lustre when rubbed. All appearance of vegetable structure nearly obliterated	

TABLE I.—*continued.*

Number of Specimen.	Specific Gravity.	Description.	Locality from whence obtained, and General Observations.
10	0·398 to 0·471	A good compact peat of a blackish brown colour, principally consisting of moss, but having a good deal of roots of Erica, and of grasses, carex, and an intermingled vegetable structure, a good deal obliterated. Used extensively in Dublin as a fuel	From the Riversdale Bog, which is a detached part of the Bracklin, Lysclogher, and Kilconnican Bogs, which cover a surface of 9634 acres, near the town of Kinnegad, and lying immediately on the banks of the Royal Canal, and close to Hyde Park demesne. Highest part of bog above high-water level in Dublin Bay, 272·9 feet; lowest part of drainage below the summit of the bog, 60·9 feet. Average depth of Riversdale Bog, 12 to 13 feet, and of the great great bog, about 23 feet, reaching in some places 36 feet.
11	0·984 with a few bricks from 0·445 to 0·496	An excessively hard, black, compact peat. Vegetable structure completely obliterated. Some bricks of peat exhibit a perfectly resinous concboidal fracture. Scales of fir trees and twigs of birch, alder, &c., sometimes occur. A valuable fuel, for which purpose a considerable quantity is sent to Dublin	From the Baltinoran and Rawson Bogs, close to the town of Kinnegad. This bog covers only a surface of 1382 acres, but it may be considered as merely a detached part of the great bogs of Toor, Mullagharush, Sidebrook Ring, Tubberdaly, &c., and which contain about 20,000 acres, with an average depth of 20 feet. Highest point of Baltinoran Bog above high-water in Dublin Bay, 267·2 feet, and lowest part of drainage below the summit of the bog, 40·6 feet. Average depth, 18 feet.
12	0·650 to 0·713	A very dense dark reddish brown peat. Vegetable structure only occasionally perceptible, with the exception of some leaves of the *Iris pseudacorus*, or common flag, and of carex, and a few roots of Erica quite perfect, but probably these are derived from an admixture of the *skraw*, or surface layer of peat	From Anadruce and Cloncreim, near the eighteenth lock on the Royal Canal, about one mile from Hyde Park. This bog covers 1,288 acres. Its highest point above high-water in Dublin Bay, is 255·5 feet; lowest part of drainage below the summit of the bog, 24·5 feet. Average depth, about 22 feet, sometimes reaching 35 feet.
13	0·476 to 0·571	Rather dense peat of a dark reddish brown colour. Structure of Sphagnum very indistinct, but leaves of the flag, and stems and roots of Erica occur in a perfect state. Structure compact . .	From the bogs of Rathconnel, Wood Down, and Great Down, near the Royal Canal, two miles east of Mullingar. Average depth of bog, 18 feet; greatest depth, about 30 feet. Highest point of bog above Dublin Bay, 336·2 feet, and lowest part of drainage below summit of bog, 43·5 feet.
14	0·219 0·220 to 0·303	1. Upper layer of fibrous bog. Moss spongy, and of a yellowish red colour. Composed of almost pure unaltered Sphagnum, with occasional roots of carex, erica, &c.	The bogs in the immediate neighbourhood of Banagher are Coolgowny and Garbally, 3688,—Glaston and Streamstone, 1341 acres. The latter is 1½ miles from the Shannon, and is in many places nearly as low as its summer level. Between these bogs and the

TABLE I.—*continued.*

Number of Specimen.	Specific Gravity.	Description.	Locality from whence obtained, and General Observations.
15	0·380 to 0·409	2. A rather compact peat, of a reddish brown colour. Vegetable structure still very perceptible, but impossible to distinguish species. Roots of erica very abundant, but greater part evidently derived from mosses . .	Shannon are several patches of red bog of no great depth, and generally in the condition of quagmire. Immediately east of these latter are several large bogs, lying along to the south of the Grand Canal. The total number of acres in this group of bogs is 36,417, with an average depth of more than 20 feet.
16	0·362 0·421 0·527	3. A still more compact peat than No. 15, but still consisting of fibrous or red bog. Colour, a light reddish brown. The structure of the mosses still visible, but species could not be discriminated. Roots and leaves of carex exceedingly abundant	,, ,,
17	0·300 0·315 to 0·356	Light surface peat of a pale reddish brown. Mass spongy, and composed of almost unaltered Sphagnum, with a few stems and roots of erica .	From the bogs of Clonfert and Kilmore, at the mouth of the River Suck where it falls into the Shannon near Banagher. These bogs cover 9615 acres, and form part of a group of bogs which stretch to Ballinasloe, and include altogether 14,481 acres, with an average depth of 30 feet. The bottom of the bog is frequently 10 feet below the surface-water in the Suck or Shannon, but there is in every part sufficient fall from the surface.
18	0·924 with a few bricks as low as 0·466	A rather compact peat of a light reddish brown colour, evidently fibrous or red bog, but near where it passes into compact black peat. Structure of mosses gradually disappearing, but still quite perceptible. Abundant remains of carex and of the grasses	
19	1·058 with a very few bricks as low as 0·546	Exceedingly dense, dark, blackish brown peat. Fracture earthy, sometimes conchoidal. Vegetable structure almost completely disappeared, but where apparent, remains of carex, grasses, and erica abundant . .	From Athlone Bog, which covers only 891 acres, but it forms part of a very large and important tract of bogs, stretching from below Shannon Bridge to Lough Rae on the one side, and to Ballinasloe on the other, and is then bounded or inclosed on two sides by the rivers Shannon and Suck. The whole tract of bog covers 29,063 acres. Athlone Bog has an average depth of 25 feet, and is sufficiently elevated above the Shannon to be entirely drained.
20	0·401 0.500 to 0·541	A rather dense peat of a blackish brown colour, in which the structure of the moss is no longer	Specimen, most probably, from either Curragh or Clonburne Bogs, near Shannon Bridge, at the mouth of the Suck, and thus forming part of the last-men-

TABLE I.—*continued.*

Number of Specimen.	Specific Gravity.	Description.	Locality from whence obtained, and General Observations.
		visible, but abounding in remains of carex, grasses, and roots and stems of erica. These latter appearing to have grown on a dense peat, and finally got mixed up with the soft moss	tioned district. The Cullagh and Clonburne Bogs lie east of the Suck, which separates them from the Clonfert Bogs on the west side. These bogs cover 3394 acres, and are from 27 to 30 feet average depth, and are very well capable of being drained. The entire district of bogs on both sides of the Suck covers about 86,000 acres.
21	0·485 to 0·591 and 0·811	1. A dense peat of a dark reddish brown colour. Remains of carex and grasses very abundant; but Sphagnum much compressed, and structure very indistinct . .	Nos. 21, 22, 23, 24, 25, 26, 27, are specimens of the peats employed as fuel in the steam-vessels on the Middle Shannon, and obtained from the bogs along the river.
22	0·276 to 0·284	2. A light fibrous peat of a reddish brown colour. Evidently formed from a great number of plants. Structure of moss very distinct. Species of Sphagnum and Hypnum distinguishable. Remains of carex and grasses, with roots of erica, and bark of birch, and probably alder; twigs abundant.	
23	0·387 0·611 to 0·641	3. A very dense peat of a blackish brown colour. Mass compact. Vegetable structure very indistinct. Remains of carex abundant and roots of erica frequent. An excellent turf for fuel .	
24	0·724 to 0·983	4. A very dense blackish brown compact peat. Vegetable structure almost obliterated. Fracture earthy. Full of tubes of the bark of hazel, birch, and alder, and occasionally scales of pine bark, and leaves of carex and grass	
25	0·241 0·464 to 0·501	5. A rather dense reddish brown peat. Structure of mass very indistinct. Carex leaves still un-	

TABLE I.—*continued.*

Number of Specimens.	Specific Gravity.	Description.	Locality from whence obtained, and General Observations.
		altered, and occasionally a few fragments of twigs and roots	
		6.	
26	0·363 0·419 to 0·540	A rather compact and moderately dense peat of a dark reddish brown colour. Structure of moss almost obliterated. Abundance of leaves, stalks, and roots of carex, grasses, &c.	
		7.	
27	0·725 to 0·991	An exceedingly dense peat of a jet black colour. Structure of moss completely disappeared. Fracture earthy, tending to conchoidal, assuming resinous lustre when rubbed. Abundance of remains of carex leaves, and a very few fragments of bark, apparently of hazel	

TABLE II.—Representing the Percentage of Water, Ash, Charcoal, Volatile Matter, of the preceding specimens of Peat.

Number of Specimen.	Water (Air Dried).	Ash.	Charcoal.	Volatile Matter.	Number of Specimen.	Water (Air Dried).	Ash.	Charcoal.	Volatile Matter.
1	16·560	1·320	36·480	45·640	15	21·687	1·997	35·846	40·470
2	19·452	1·992	31·699	46·857	16	22·205	1·383	37·537	38·875
3	16·394	3·305	38·247	42·054	17	21·024	1·400	38·085	39·491
4	17·091	2·629	34·522	45·758	18	20·323	1·538	37·574	40·565
5	18·570	1·986	34·102	45·342	19	29·734	2·349	33·641	34·276
6	19·400	6·840	37·102	36·650	20	22·161	1·190	38·938	37·711
7	16.497	2·745	36·695	44·063	21	24·383	1·345	39·600	34·672
8	10·446	4·750	41·031	43·773	22	21·004	2·474	35·470	41·052
9	18·003	7·898	38·768	35·331	23	33·270	2·301	32·491	31·938
10	18·915	1·251	35·202	44·632	24	29·567	2·976	36·463	31·004
11	23·903	5·266	34·023	36·808	25	24·783	1·317	33·520	40·380
12	23·152	3·100	40·300	33·448	26	23·433	1·316	39·554	35·697
13	19·704	1·920	34·400	43·976	27	20·681	2·464	36·520	40·335
14	23·812	1·828	35·186	39·174					

TABLE III.—Representing the Percentage of Nitrogen in different Peats.

Number of Specimen.	1.			2.		
	Quantity of Peat employed.	Quantity of Platinum found.	Nitrogen per cent.	Quantity of Peat employed.	Quantity of Platinum found.	Nitrogen per cent.
	Grains.	Grains.		Grains.	Grains.	
1	17·65	1·401	1·1278	21·84	1·944	1·2648
2	18·41	1·906	1·4713	11·66	1·174	1·4316
3	17·47	1·062	0·8641	13·41	0·846	0·8971
4	19·10	2·550	1·8972	9·82	1·296	1·8761
5	24·87	1·833	1·0476	12·60	0·957	1·0798
6	27·61	1·645	0·8467	13·41	0·806	0·8547
7	16·42	1·456	1·2601	22·60	1·314	1·2576
8	36·58	2·93	1·1382	14·92	1·177	1·1212
9	42·68	2·32	0·7724	13·97	0·827	0·8416
10	11·03	0·401	0·5166	21·60	2·834	0·6071
11	29·971	3·663	1·7364	14·03	1·623	1·6437
12	23·954	1·315	0·7799	15·10	0·795	0·7486
13	12·464	0·282	0·40467	24·70	0·866	0·4986
14	15·57	1·012	0·9234	22·68	1·606	1·0062
15	7·679	0·65	1·2026	25·81	2·198	1·2104
16	12·884	0·451	0·4973	19·67	0·716	0·5172
17	10·72	0·786	1·0417	18·75	1·394	1·0568
18	14·294	0·683	0·6788	22·46	1·132	0·7162
19	14·18	1·241	1·2434	21·97	1·935	1·2518
20	11·604	0·789	0·9660	23·37	1·596	0·9706
21	12·624	1·061	1·1940	17·11	1·426	1·1842
22	11·824	0·798	0·9588	19·27	1·288	0·9502
23	23·15	1·649	1·0120	11·08	0·791	1·0147
24	11·014	1·315	1·6962	19·07	2·261	1·6847
25	16·680	1·193	1·0161	21·61	1.551	1·0200
26	11·64	0·792	0·9678	23·41	1·625	0·9864
27	19·72	1·320	0·9510	13·91	0·948	0·9684

TABLE IV.—Representing the Percentage of Tar, Water, Charcoal, and Gas, obtained from the specimens of Peat subjected to Distillation.

Number of Specimen.	Corresponding Number on Table No. 1.	Locality from whence obtained.	Water.	Tar.	Charcoal.	Gas.
1	2 and 3	Mount Lucas Bog, Phillipstown . .	23·600	2·000	37·500	36·900
2	7	Light surface peat from the Wood of Allan	32·273	3·577	39·132	25·018
3	9	Black compact peat Wood of Allan .	38·102	2·767	32·642	26·489
4	4	Ticknevin . . .	33·628	2·916	31·110	32·346
5	Ditto	Ditto, distilled with retort heated to redness . . .	32·098	2·344	23·437	42·121
6	22	Upper Shannon . .	38·127	4·417	21·763	35·693
7	24	Upper Shannon . .	21·819	1·462	18·973	57·746
			219·647	19·483	204·557	256·313
			31·378	2·787	29·222	36·616

TABLE V.—Representing the Percentage of the principal Commercial Products obtained from the Distillation of Peat, with the corresponding values given by Mr. REES REECE.

Number of Specimen.	AMMONIA.			ACETIC ACID.			Pyroxylic Spirit or Naphtha.		Paraffine.		Volatile Oils.		Fixed Oils.	
	Ammonia. (N.H3.)	Corresponding Quantity of Sulphate of	Quantity of Sulphate of, obtained by Mr. Reece.	Acetic Acid. $(C_4, H_3, O_3, + H\ O)$	Corresponding Quantity of Acetate of Lime.	Quantity of Acetate of Lime stated by Mr. Reece.								
1.—Phillipstown. General Table No. 3.	0·302	1·171	100 tons of peat yield 1 ton of sulphate of ammonia, = 1·00 per cent.	0·076	0·111	100 tons of peat yield 14 cwt. of grey acetate of lime, = 0·70 per cent.	0·092	Reece:—100 tons of peat yield 52 gallons, at 8 lbs. to the gallon, = 0·185 per cent.	0·024	Reece:—100 tons of peat yield 300 to 350 lbs. = 0·133 to 0·156.	0·684	According to Reece 100 tons of peat yield about 200 gallons of oil, which at 9 lbs. to the gallon, is = 1800 lbs. = 0·803 per cent.	0·469	According to Reece 100 tons of peat yield 98·6 gallons of oil, which at 9 lbs. to the gallon, is = 887·4 lbs. = 0·396 per cent.
2.—Light surface Peat Wood of Allan. Table No. 7.	0·187	0·725		0·206	0·302		0·171		0·179		0·721		0·760	
3.—ood of Allen, dense. Table No. 0.	0·393	1·524		0·286	0·419		0·197		0·075		0·571		0·565	
4.—Ticknevin. Table No. 4.	0·210	0·814		0·196	0·287		0·147		0·170		1·262		0·617	
5.—Ditto distilled at full red heat.	0·195	0·756		0·208	0·305		0·161		0·196		0·816		0·493	
6.—Light surface peat —Shannon. Table No. 22.	0·404	1·567		0·205	0·299		0·132		0·181		0·829		0·680	
7.—Shannon, dense. Table No. 24.	0·181	0·702		0·161	0·236		0·119		0·112		0·647		0·266	
7)	1·872	7·259		1·338	1·959		1·019		0·937		5·530		3·850	
Average . .	0·268	1·037		0·191	0·280		0·146		0·134		0·790		0·550	

TABLE VI.—Representing the Elementary Composition of the varieties of Peat subjected to Distillation.

Number of Specimen.	Corresponding No. on Table No. 1.	Locality from whence obtained.	Quantity of Peat employed.	Water found.	Carbonic acid found.	Carbon.	Hydrogen	Oxygen.	Nitrogen (Mean).	Ash per cent.
			Grains.							
1	2	Surface peat, Phillipstown.	6·846	4·209	14·440	58·694	6·971	32·883	1·4514	1·992
2	3	Dense peat, Phillipstown.	8·283	4·395	17·761	60·476	6·097	32·546	0·8806	3·305
3	7	Light surface peat, Wood of Allen.	7·166	4·148	15·303	59·920	6·614	32·207	1·2588	2·745
4	9	Dense peat, Wood of Allen.	9·304	4·451	19·175	61·022	5·771	32·400	0·8070	7·898
5	4	Tichnevin .	8·174	4·816	17·541	60·102	6·723	31·288	1·8866	2·629
6	22	Upper Shannon—No. 2.	8·305	4·282	17·825	60·018	5·875	33·152	0·9645	2·474
7	24	Upper Shannon—No. 4.	8·667	4·250	18·886	61·247	5·616	31·446	1·6904	2·976

Note.—In calculating the percentage of the carbon, hydrogen, &c., the ash was first subtracted, in order that the true composition of the organic portion of the peat might be obtained.

TABLE VII.—Representing the proportions of Water, Tar, Ash, and Gas, obtained by the Distillation of Peat in a blast of air, with the corresponding results obtained with a closed retort.

Number.	Corresponding No. in Table 1.	Locality of Specimen.	Water.		Tar.		Ash.		Gas.
			In blast of Air.	In closed Retort.	In blast of Air.	In closed Retort.	In blast of Air.	In closed Retort.	In blast of Air.
1	7	Light surface peat, Wood of Allen.	31·678	32·273	2·510	3·577	2·493	2·745	63·319
2	9	Dense peat, Wood of Allen.	30·663	38·102	2·395	2·767	7·226	7·898	59·716
3	24	Shannon—No. 4.	29·818	21·819	2·270	1·462	2·871	2·976	65·041

TABLE VIII.—Representing the Percentage of Ammonia, Acetic Acid, Pyroxylic Spirit, Paraffine, and Oils obtained by the Distillation of Peat in a blast of air, and the corresponding results obtained with a closed retort.

Number.	Corresponding No. in Table 1.	Locality of Specimen.	Ammonia.		Acetic Acid.		Pyroxylic Spirit.		Paraffine.		Oils.	
			In a blast of Air.	In closed Retort.	In a blast of Air.	In closed Retort.	In a blast of Air.	In closed Retort.	In a blast of Air.	In closed Retort.	In a blast of Air.	In closed Retort.
1	7	Light Surface Peat, Wood of Allen .	0·322	0·187	0·179	0·206	0·158	0·171	0·169	0·179	1·220	1·481
2	9	Dense Peat, Wood of Allen .	0·344	0·393	0·268	0·286	0·156	0·197	0·086	0·075	0·946	1·136
3	24	Shannon, No. 4. .	0·194	0·181	0·174	0·161	0·106	0·119	0·119	0·112	1·012	0·913
		3)	860	761	621	653	420	487	374	366	3·178	3·530
Average.			287	254	207	218	140	162	125	122	1·059	1·177

TABLE IX.—Representing the Composition of the Ashes of the different Peats described in Table I.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV·
Potash.	0·362	1·323	0·461	0·401	0·221	0·198	0·491	0·211	0·247	0·641	0·347	0·181	0·291	0·966
Soda	1·427	1·902	1·399	1·330	0·712	0·590	1·670	0·651	0·496	1·875	0·679	0·550	0·586	1·038
Lime	26·113	36·496	40·920	37·873	33·240	25·860	33·037	29·716	24·944	22·702	45·581	29·323	38·692	35·113
Magnesia	3·392	7·634	1·611	5·127	1·904	1·207	7·523	1·204	1·285	6·809	1·256	3·425	2·372	4·687
Alumina	4·180	5·411	3·793	0·271	0·240	0·371	1·686	0·298	0·360	1·109	0·129	0·672	0·408	1·627
Peroxide of Iron	11·591	15·608	15·969	14·802	12·760	18·746	13·281	20·372	19·405	29·854	15·974	19·095	15·537	14·322
Phosphoric Acid	1·461	2·571	1·406	1·257	1·222	0·874	1·438	1·066	0·242	2·019	0·188	0·975	0·878	0·828
Sulphuric „	12·403	14·092	14·507	11·814	21·470	23·630	20·076	22·664	10·742	16·381	44·371	16·238	14·822	25·409
Hydrochloric „	1·568	1·482	0·983	1·367	0·840	0·622	1·747	0·439	0·335	1·591	0·337	0·636	0·657	1·090
Silica in Compounds decomposable by Acids .	0·980	3·595	1·111	1·002	1·672	0·896	2·148	0·645	1·082	0·737	1·043	3·255	5·808	5·607
Sand and Silicates undecomposable by Acids .	22·519	2·168	2·107	4·722	13·147	14·430	7·683	11·180	26·789	14·505	2·653	8·884	14·181	4.340
Carbonic Acid	13·695	7·761	15·040	19·722*	12·060	12·240	8·340	10·782	13·890	1·470	16·120	15·984	5·842	5·003
Total	99·691	100·043	99·307	99·688	99·488	99·654	99·120	99·228	98·817	99·693	99·678	99·218	100·74	100·030

* The quantity of carbonic acid found by experiment is in nearly every case much less than that required to saturate the lime, supposing the whole of the sulphuric acid to exist as sulphate of lime; this is accounted for by the high temperature necessary to incinerate the peat having driven off the greater part of the CO.

TABLE IX.—Representing the Composition of the Ashes of the different Peats described in Table I.—*continued.*

	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.	XXIII.	XXIV.	XXV.	XXVI.	XXVII.
Potash	0·407	0.665	6·668	0·280	0·744	1·667	·271	0·146	0·247	0·219	0·370	0·028	0·158
Soda	2·074	2·605	1·709	2·180	0·704	2·823	1·491	0·466	1·150	0·855	2·628	2·832	0·527
Lime	33·397	33·554	31·553	30·744	40·623	20·907	13·667	8·492	22·332	40·079	27·732	26·551	12·432
Magnesia	11·293	9·229	9·439	9·237	4·352	15·252	16·994	4·702	5·608	4·035	6·875	12·580	3·095
Alumina	1·627	0·677	1·707	2·027	1·671	2·034	0·259	10·705	0·932	0·895	1·521	3·298	5·991
Peroxide of Iron . . .	18·500	18·366	6·012	19·797	10·368	17·040	26·644	15·052	29·970	14·160	7·451	12·116	30·725
Phosphoric Acid . . .	0·744	1·300	25·602	1·290	1·114	1·447	1·339	1·557	0·699	0·632	1·670	2·022	0·526
Sulphuric „	13·550	23·505	1·286	20·857	24·208	23·375	22·691	13·974	31·612	22·295	20·389	22·401	14·518
Hydrochloric „ . . .	2·804	3·263	0·698	3·128	1·052	1·424	1·180	0·196	0·993	0·781	2·932	2·518	0·151
Silica in Compounds decomposable by Acids .	5·998	4·449	5·159	3·096	6·317	6·634	2·719	12·476	2·751	1·295	7·709	5·474	9·101
Sand and Silicaies undecomposable by acids .	6·593	3·040	6·282	3·163	3·710	10·682	11·673	31·198	3·775	5·496	10·088	17·711	22·721
Carbonic Acid . . .	3·006	··	9·864	3·570	4·981	6·721	··	··	··	9·101	10·460	1·220	··
Total	99.993	99·653	99·979	99·369	99·844	100·006	98·928	98·964	100·069	99·843	99·825	98·751	99·945

Remarks on the results presented by the Tables.

1. That the percentage of ash, as a general rule, in the peats of the Bog of Allen is very small.
2. That the percentage of sulphate of lime and of phosphoric acid, although it is in general greater in the deep layers of turf, does not appear to be dependent upon position in the bog, but rather upon local circumstances.
3. That nearly the whole of the alkalies originally existing in the plants which have formed the peats, have been removed, together with a large amount of the phosphates, during the formation of the peat.
4. That the amount of silica is, in general, very small, especially in the true fibrous peats.
5. That, on the whole, the ash of peat must form an excellent manure, provided other sources of obtaining alkalies exist.
6. That, as a general rule, the lower layers of peat of the same bog contain less nitrogen than the surface layers, but, nevertheless, no general rule can be formed upon the subject, as some varieties of the densest peats yield a larger amount of that element than the upper or lighter kinds;—in some cases even double as much. The percentage of nitrogen in a specimen of peat, appearing to depend in a great measure upon the relative proportion of the remains of seeds, &c., which may exist in it.
7. That the results of the carbon and hydrogen determinations show a singular uniformity of composition in the turfs, if we subtract the percentage of ash, and that the lower peats in general contain more carbon than the surface layers—results which agree in the most perfect manner with those obtained by Mulder and Regnault, which are given in the Appendix.
8. That the determinations of charcoal have given very high results, but such as correspond perfectly with the results of the carbon and hydrogen determinations, the densest peats giving the highest percentage, the limits of difference being, however, very narrow.
9. That the products of distillation of equal weights of dense peat and of light surface peat *are very nearly of equal value:* a point of considerable importance.
10. That the principal difference observed between the proportions of the products of distillation of different peats is in the amount of *water* and of charcoal, both these being in general less in the dense peats than in the surface peats, owing to the fact that the water is liberated very slowly from the former, and has a longer time to act upon the surface of each brick, which generally attain a high temperature before the centres are even sometimes reached by the heat. A fact which is well exemplified by the results of the distillation of No. 7, Table IV.
11. That the effects of an increase of temperature, such as we could command, in the distillation of peat, seems to act nearly in the same manner, the amount of charcoal being less, and the amount of gas greater. The

relative proportion of the gases produced was evidently different, but all the other products were formed in nearly the same proportions. In the Ticknevin peat, the only one distilled at two different temperatures, the principal points of difference, besides that of the charcoal and gas already mentioned, was in the proportion of resins in the tar, which was much larger in that distilled at a low heat, than in that distilled with the retort heated to redness—a point which we have already noticed as being probably also the real difference between the tar upon which we operate and that obtained by Mr. Reece, and which therefore explains why he succeeded in purifying his tar by sulphuric acid. The difference is, however, not very large, at least not sufficiently so to warrant us in premising that this is the real cause why the sulphuric acid process did not succeed with us.'

12. That the whole of the nitrogen existing in peat is not converted into ammonia when it is distilled—and that the moderately dense peats appear to be the best suited for its formation, although such a rule cannot be considered as general, as is proved by the results obtained with the lightest of all the peats, No. 6, Table IV.
13. That in all the essential points our experiments confirm the statements of Mr. Reece, as to the *quantities* of the different products obtained in the distillation of peat; and in one respect do still further, inasmuch as they show that the upper layers of fibrous or red peat, which offers such an impediment to the reclamation of bogs, and is almost valueless as a fuel, is, as far as percentage of the ingredients yielded, of equal value with the lower layers of compact peat, which answers very well as fuel, and which is capable of affording the materials of soil, and which, on the other hand, would be much more expensive to cut than the upper layers, which require little or no drainage.

No. VII.

SUPPLEMENTAL NOTE OF THE RESULTS OBTAINED BY PREVIOUS EXPERIMENTERS ON PEAT.

In order to enable those interested in the matter to compare our results with those of other chemists who have examined the subject, we shall give, in the form of an Appendix, such of their results as have any connection with the points which we had under examination.

A great number of papers have been published, from time to time, upon the subject of peat, especially in Germany; but very little has really been done towards a true history of the subject, the attention of every investigator having been directed to the study of the condition of the organic matter soluble in potash and ammonia.

Brandes and Gruner,* in an analysis of a turf from Pyrmont, showed the presence of sulphate of protoxide of iron, basic persulphate of iron, gypsum, and traces of phosphate of lime. In 1825 Bergema[*] published a very singular analysis, in which, among other matters, he states that he obtained oxide of iron 0·42, silica 3·8, sulphate of lime 4·5, phosphate of lime 2·7 !!! per cent. L. Oberlin and L. A. Buchner [†] examined the ash of a dark brown fibrous moor peat from the neighbourhood of Strasburgh, which was easily cut, and readily burned with flame, and left 0·18 of ash, which was reddish gray, felt sandy, tasted saline-earthy, and was not fusible before the blowpipe. It was found composed of—

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* Berz. Jahrb. VII. 206.

a.—Peat soluble in water—consisting of common salt with a little gypsum	0·19
b.—Peat insoluble in water—consisting of carbonate of lime, carbonate of magnesia, phosphate of magnesia, phosphate of alumina, oxide of iron, sulphate of lime and silica	0·81
	1.00

This ash contained neither free or carbonated alkalies or sulphur compounds. None of the other analyses of ash published are of any value.

The following table contains the results of all the determinations of charcoal and volatile matter which we could find.

	1	2	3	4	5	6	7	8
Water	..	..	..	30·5	..	..	..	..
Charcoal	21·0	23·0	17·3	22·0	23·82	22·67	19·14	23·66
Volatile Matter	72·0	72·2	65·3	39·2	73·63	75·50	72·80	70·10
Ash	7·0	4·8	17·4	8·3	2·55	1·83	8·06	6·24
	100·0	100·0	100·0	100·0	100·00	100·00	100·00	100·00

Nos. 1 and 2 were analyzed by Berthier.[‡] No. 1 was from Rue, in the department of Somme; and No. 2 from New Abbeville, in the same department.

No. 3.—Was a turf from Velleron (Vaucleuse), between Avignon and l'Isle. It was black light, and consisted almost entirely of moss. It was analysed by Diday.[§]

No. 4.—Examined by Sauvage,[‖] was from Sécheval, in the arrondissement Rocroy and Nézières. In these districts the turf occurs in large tracts on plateaus of the Ardennes, or at the sources of the small streams, and in narrow valleys. The specimen examined was of excellent quality, brown, and pretty dense.

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[*] Buchner's Report, XXI. p. 498.

[†] Buchner's Report d. Pharm., 1833, XLVI. p. 185.; and Leonhard and Bronn, N. Jahrb d. Mineralogie. 1837, p. 375.

[‡] Annal des Mines 3 ème Sèr. XI., p. 446.

[§] Annal des Mines 3 ème Sèr. XIV., 299.

[‖] Annal des Mines, I., 521

Nos. 5, 6, 7, and 8 were examined by Sir Robert Kane.* No. 5 was light surface peat, from Cappoge, in Kildare. No. 6, ditto, from Kilbeggan, in Westmeath. No. 7 was deep seated turf from Kilbaha in the County Clare; and No. 8, ditto, from Cappoge.

The following table exhibits a series of determinations of carbon and hydrogen of different peats:—

Turf.	REGNAULT.†			MULDER.‡		
	Vulcaire near Abbeville.	Long near Abbeville.	Champ de Feu near Framont.	Friesland compact Turf.	Friesland surface Turf.	Holland.
Carbon . . .	60·40	60·89	61·05	59·42	60·41	59·27
Hydrogen . . .	5·96	6·21	6·45	5·87	5·57	5·41
Oxygen . . .	33·64	32·90	32·50	34·71	34·02	35·32
Ash in 100 parts of Turf	5·58	4·61	5·33	3·80	0·91	14·25

Turf from	SIR ROBERT KANE.§			Woskressensky.‖
	Kilbeggan in Westmeath.	Kilbaha in Clare.	Cappoge in Kildare.	Ochta in Eastern Russia
Carbon . . .	61·04	51·13	51·05	39·084
Hydrogen . . .	6·67	6·33	6·85	3·788
Oxygen . . .	30·46	34·48	39·55	51·088
Ash	1·83	8·06	2·25	6·040
	100·00	100·00	100·00	100·000

It is to be regretted that no description has been published of the turf analysed by Woskressensky, as it differs from all the others in a remarkable degree.

The most important paper in an economic point of view which we have met with is one by Wellner.¶ This investigation was undertaken with a view to substitute, if possible, turf for wood in the manufacture of alum at the Prussian alum works at Schwemsal, in the grand duchy of Saxony. The depositions of turf in the neighbourhood, although of no great thickness, are very numerous, and filled with trunks and roots of trees. Not far also from the works, a few leagues to the eastward, on the right banks of the Mulde, occurs the Schnadizer turf-bog, lying upon decomposing alum slate, and belonging to the Count of Hohenthal, who obtains annually about 5,000,000

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[*] Proceedings of the Royal Irish Academy, vol. II., 1840-44, p. 538.

[†] Annal der Pharm. XXV., p. 270.

[‡] Berz. Jahrb. XIX. 570.

[§] Proceedings of Royal Irish Academy, vol. II., 1840-44, p. 538.

[‖] Bulletin Scient. Petersburg, and Leonhard and Bronn, Neues Jahrbuch, 1850, p. 617.

[¶] Untersuchung einiger Tecfsorton und Bomerkungen über das in solchen wahrgenemene Kali.—'Erdmann's Journ.' für Techn. u. Okon. Chemie., 1832, XIV., and Leonhard u. Bronn, Neues Jahrb. 1833, p. 250.

compressed turf bricks from it. The facility thus afforded for obtaining good turf, and the high price of wood, as well as the great quantity necessary, rendered a comparison of the relative values of the turf and wood of great importance. The bricks experimented upon contained about 330 cubic inches, and the distillation was performed in a strong sheet-iron cylinder, from which the products were condensed, consisting of a thick yellow, becoming brownish towards the end, oil, and a stinking pyrogenous water. The gaseous products were not further examined, but were considered owing to the facility with which they burned, as carbonic oxide and carbo-hydrogen, and was estimated as loss. The coke obtained, was burned in a small furnace, and the residual ash weighed. Varieties which contained much wood and plants gave, by continued strong heat, solid slags, which gradually decomposed in the air. A heap of such slags exposed to the air during the winter exhibited in the centre, which had become heated, a mass or nucleus which had sintered together, and which was several ells broad, and had a strong smell of sulphureous acid. It was lixiviated, a part of the ley evaporated to one-fourth its bulk and crystallized, and without the addition of either potash or ammonia, octohedral crystals of potash, alum, were obtained, contrary to the general belief that turf contains no potash. The potash in this case must either have been derived from the admixed slate, or from the decomposing plants mixed up with the peat, because, under similar circumstances, potash has been observed in the turf employed at the vitriol works at Trossin and Moschewig; and indeed, as the results of our analyses show, it is never wholly absent from moor peat.

We have not thought it necessary to reduce the weights to the English standard, as the value of the table consists entirely in the relative proportions of the products to one another. The Prussian pound, too, is very little more than an English pound. Thus, 1 pfund (Berlin), is = 9747 Dutch assen or grains; and 1 pound English is = 9439 ditto. Hence, they may for our purposes be considered as practically the same. The Prussian pound is divided in 32 *loth*, and each *loth* into four *quentchen*. Hence, one loth is equal to about half an ounce English, and one quentchen to about one apothecaries' drachm.

TABLE A.—Results of Experiments made on the Dry Distillation of a Turf-Brick.

Varieties of Turf.	A Turf Brick had						This gave by dry Distillation,						By incineration of the Charcoal.				In the Whole Turf, Weight of Combustible.	
	Fresh, 330 cubic inches. Weight in Loths.	When dry.		Loss by Drying.		Specific Gravity.	Empyreumatic Oil, Acids, &c.		Gas evolved.		Charcoal.		Volatile Products.		Ash.			
		Volume in cubic inches.	Weight in Loths.	Volume in cubic inches.	Weight in Loths.		Loth.	Quentchen.	Loth.	Quentchen.	Loth.	Quentchen.	Loth.	Quentchen.	Loth.	Quentchen.	Loth.	Quentchen.
1.—From Crina, upper layer .	373	79·4	53	250·6	320	0·5471	14	3	15	3	22	2	17	0·5	5	1·50	47	2·50
2.— ,, middle layer.	318	58·5	46	241·5	272	0·6550	16	2	12	3	16	3	14	1·5	2	1·75	43	2·25
3.— ,, under layer .	320	45·5	24	284·5	296	0·4323	33	5	5	0·5	15	. .	11	0·5	3	3·50	20	0·50
4.—Mass of turf exposed during winter.	334*	129·5	61	200·5	283	0·3873		1·5	20·2	0.2	32	0·4	14	2·75	17	2·25	43	1·75
5.—Schmerz	309	81.9	63·5	241·1	245·5	0·6355	15	3·5	10	. .	37	2·5	26	. .	11	0·50	22	1·50
6.—Schnaditz	358*	65·0	58	265·0	305	0·7314	14	. .	13	2	31	. .	10	. .	21	. .	37	. .
7.—Hahnholz	345·5	80·6	87·5	149·4	258	0·7846	15	3	19	0·5	42	2·5	13	3·5	28	3	48	3
8.—Fragments of turf cemented with 0·18 per cent. of Hahnholz.	316·75*	153·4	115·5	175·6	211·25	0·6171	33	. .	28	. .	54	2	41	. .	13	2	102	. .

Note.—The numbers marked thus * are incorrectly stated in the memoir, as they do not correspond with the total of the parts.